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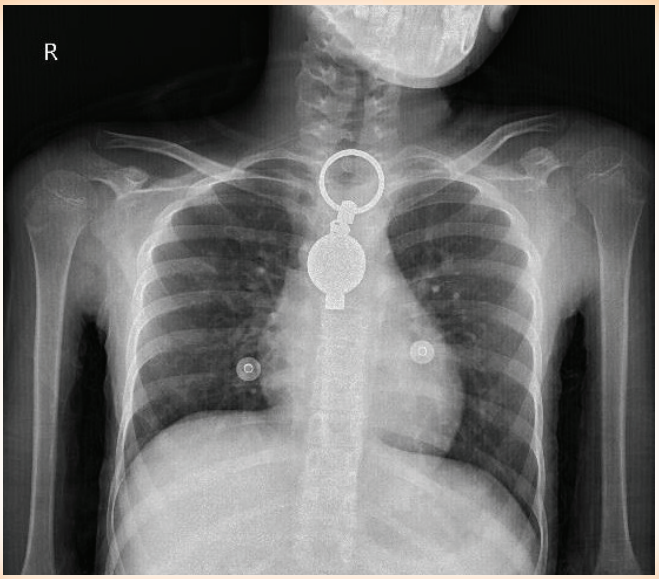

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Table of Contents

Volume 9 Number 2 August 2024 eISSN 2548-0316

Original Articles

61 **Association between hypertrophic scars and postoperative adhesions: the importance of re-do surgery**
Tugba Cosgun, Talha Dogruyol, Cagatay Tezel

66 **Factors affecting mortality in esophageal perforation**
Gökhan Kocaman, Yusuf Kahya, Murat Özkan, Bülent Mustafa Yenigün

72 **Do atmospheric pressure and air pollution affect the incidence of primary spontaneous pneumothorax?**
Aylin Canavar, Melek Erk, Yunus Seyrek, Ali Murat Akçıl, Nazlı Cansever, Mehmet Ali Bedirhan, Levent Cansever

78 **Air leak grading in primary spontaneous pneumothorax is useful to predict prolonged air leak**
Serkan Yazgan, Ahmet Üçvet, Banu Yoldaş, Ezgi Çimen Çelik, Soner Gürsoy, Bahar Ağaoğlu Şanlı

Review

85 **VATS sleeve resections**
Melike Ülker, Esra Gözügül, Muzaffer Metin

91 **Pediatric esophageal emergency: practical algorithms for the diagnosis and treatment from thoracic surgery perspective**
M.Gökhan Pirzirenli, Selçuk Gürz, Caner İşevi, Ayşen Taslak Şengül, Yasemin Büyükkarabacak

Case Report

103 **Bilateral lower lobe pulmonary hypoplasia in adult**
M. Gökhan Pirzirenli, Caner İşevi, Yasemin Büyükkarabacak

107 **Giant solitary fibrous tumor of the diaphragm supplied by aortic branches**
Hasan Ekrem Camas, Suleyman Emre Akin, Veysel Atilla Ayyildiz, Rasih Yazkan, Isa Dongel

110 **Lung-sparing procedure in delayed period pulmonary artery coil migration: case presentation**
Mehmet Çetin, Mehmet Büyükevli, Furkan Süral, Koray Aydoğdu

114 **Simultaneous excision of intrathoracic solitary fibrous tumor and retroperitoneal schwannoma with robot-assisted surgery**
Shukur Musayev, Taha Çetin, Özgür Samancılar, Özgür Çakmak, Mehmet Şenoğlu

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Original Article

Association between hypertrophic scars and postoperative adhesions: the importance of re-do surgery

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ABSTRACT

Background: Re-do surgery may be necessary for recurrent primary lung carcinoma or a different indication. However, some difficulties such as adhesions may be encountered during re-do surgeries. We hypothesized that people with hypertrophic incision scars have severe adhesions during intuitive surgery. Therefore, this study aimed to share our experience with postoperative incision scars and the amount of pleural adhesions.

Materials and Methods: Patients who underwent reoperation (with thoracoscopy and / or thoracotomy) and who had a previous operation on the same side were retrospectively evaluated. The indications of the first and second operations, degree of adhesions, need to perform thoracotomy, and keloid and scar formations of the first incision were analyzed.

Results: A total of 22 patients (mean age, 60.1 ± 9.8; range, 19-83 years) who underwent reoperation on the same side were evaluated; 18 of them underwent reoperation due to the recurrence of the first tumor. Hypertrophic scars were observed at the incision site in six (one of them was with keloid formation), advanced pleural adhesions were found in five, and thoracotomy was required in three patients due to severe adhesions. Severe pleural adhesions were observed in 7 of 16 patients without hypertrophic scar.

Conclusions: Postoperative adhesion is a major cause of difficulties and complications during repeat surgeries. More severe pleural adhesions were observed in patients who had hypertrophic scar formation in the previous incision scar, and this observation influenced the clinical approaches.

Keywords: re-do surgery, hypertrophic scar, pleural adhesion

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Introduction

Locoregional recurrence in patients who underwent non-small cell lung cancer resection has been reported in the literature with varying ranges of rates [1]. Although the treatment for locoregional recurrence is described as chemotherapy or radiotherapy in most publications, re-resection is the preferred and most beneficial treatment option in many patients, especially those with good health and without distant metastasis [2,3]. Iterative surgery is a treatment option in second primary lung cancers [2]. Campione et al argued that the second operation is a good alternative in both patients (with recurrences or second primary tumors) if the lesions are solitary and intrapulmonary localized and if patients have good cardiac and respiratory reserves [4]. As in other surgical branches, reoperations in thoracic surgery are more difficult than the first operation especially in patients with adhesions [5]. However, postoperative adhesion formation does not occur at the same level in all patients with similar surgical procedures. While planning any operation, surgeons should consider the specific and potentially problematic features of the case and take necessary precautions. For this reason, surgeons usually wonder about the extent of adhesions before reoperations. Predictive clues that can be detected during preoperative evaluation are an interesting subject. Keloid and hypertrophic scars are described as increased fibroblast density and reactivity post-injury. Therefore, this extraordinary healing could also be seen in the thoracic cavity postoperatively. Similarly, Salim et al defined a correlation between abdominal scar and intra-abdominal adhesion in patients undergoing repeated cesarean section [6].

This study aimed to evaluate whether the previous surgical incision scar has predictive value for postoperative adhesion in the thorax.

Patients and Methods

Patients who underwent reoperation (with thoracoscopic and/or thoracotomy) and who had a previous operation on the same side were retrospectively reviewed. The indications of the first and second operations, the procedure used at the first operation, the degree of adhesions, and the need to perform thoracotomy due to adhesions were noted. Then, keloid and scar formations during the first incision were recorded. This study was approved by the Kartal Lufu Kirdar Training Hospital Institutional Review Board.

Between January 2017 and October 2022, a total of 22 patients (14 males, 8 females; mean age 60.1 ± 9.8 years; range, 19 to 83 years) who underwent reoperation on the same side were evaluated.

Results

While four of them were previously operated on for different reasons, 18 of them underwent reoperation due to the recurrence of the first tumor. Six patients had hypertrophic scars at the incision site (one with keloid formation), five had advanced pleural adhesions, and three had to undergo thoracotomy due to severe adhesions. Seven of 16 patients without hypertrophic scar had severe pleural adhesions (Table 1).

We report our experience with two patients with different indications and features.

Case 1: A 78-year-old man presented with symptoms of chronic obstructive pulmonary disease (COPD). A 4.6 cm nodule at the left upper lobe was detected with thoracic computed tomography (CT) during the evaluation due to COPD. The 18F-fluorodeoxyglucose (FDG) uptake was 5.3 at positron emission computed tomography (PET-CT) (Figure 1A). The patient had a history of

Table 1. Patient demographics and clinical characteristics.

	Number of patients	Severe adhesions	Switch to thoracotomy
Previous indication			
Malignancy	18	10	2
Recurrence or metachronous tumor			
Benign disease	4	2	1
Number of patients			
With hypertrophic scar from previous surgery	6	5	2
Without hypertrophic scar from previous surgery	16	7	1

renal cell carcinoma and nephrectomy in 2014. He also had thoracotomy and pleurectomy due to pneumothorax and prolonged air leak on the left side 20 years ago. The incision of the previous thoracotomy was about 20 cm, but the scar was mild without hypertrophy keloid formation on the scar tissue even after the thoracotomy (Figure 1B). Fiberoptic bronchoscopy failed to reveal a final diagnosis. However, we planned to perform a resection (lobectomy) due to suspicion of malignancy. In this patient, we prefer to start the operation with thoracoscopy and then switch to thoracotomy if adhesions associated with the previous operation are severe. Although adhesions are expected to be severe after pleurectomy surgery, adhesions were mild in this patient. The operation could be completed thoracoscopically because of the absence of additional difficulties related to adhesions and previous surgery (Figure 1C). A left upper lobectomy was performed due to tumor localization. Because the lesion was reported as malignant with a frozen section, mediastinal lymph node dissection was added. Postoperatively, no complications occurred, and he was hospitalized for 5 days.

Case 2: A 65-year-old woman was admitted to our clinic from the oncology department because a soft tissue density was detected during follow-up. This right lower lobe peribronchial lesion had a high SUVmax and no suspicion of metastasis in other areas (Figure 2A). The patient had a history of right lower lobe superior segmentectomy for adenocarcinoma by video thoracoscopy 2 years ago. Therefore, the high FDG uptake area was considered as a local recurrence of the first carcinoma. Completion lobectomy was suggested due to no distant metastasis, and her respiratory parameters were good. A severe hypertrophic scar on the previous operation incision was observed during the physical examination (Figure 2B). The operation was started with previous incisions. The Harmonic scalpel (Ethicon Endo-Surgery, Inc., USA) was used for dissection and coagulation of adhesions. Because of severe adhesions, hilar dissection could be started approximately 2h after the initial incision (Figure 2C). The operation was completed with two incisions in a uniportal fashion but took 3h postoperatively, she had an air leak for 2 days and was discharged on postoperative day 4.

Figure 1. PET/CT revealed that the lesion on the right upper lobe with FDG uptake **(A)**, the twenty cm previous incision was not hypertrophic **(B)**, the pleural adhesions were not severe **(C)**.

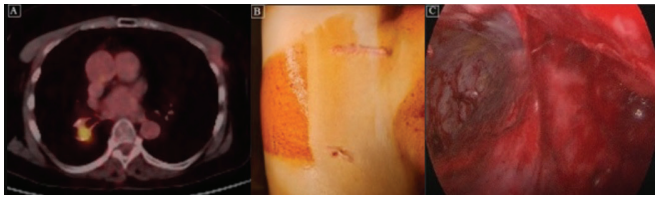

Figure 2. PET-CT images of the peribronchial lesion **(A)**, image of hypertrophic scars on the previous videothoracoscopic resection **(B)**, image of severe adhesions **(C)**.

Discussion

Ucvet et al confirmed that patients who underwent resection for lung cancer have a risk of iterative operation due to local recurrence and developed new lung cancer [7]. Postoperative adhesions are a major cause of difficulties and complications during repeat surgery. Severe adhesions may manifest several years after the initial surgical procedure [8]. The balance between fibrin deposition and degradation is important during normal healing or adhesion formation. These postoperative adhesions are the result of irritation due to infection or surgical trauma and can be considered a pathologic part of healing, especially following any surgical injury [9].

Systemic factors (including the female hormone estrogen, hypertension, and hypercytokinemic diseases) were shown to greatly worsen hypertrophic scars and keloid parameters in Ogawa's meta-analysis [10]. Histologically, localized inflammation has an important role in the formation of hypertrophic skin scars and keloids. Due to inflammation, hypertrophic scars contain inflammatory cells, increased numbers of fibroblasts, newly formed blood vessels, and collagen deposits. Proinflammatory factors, such as interleukin (IL)-1α, IL-1β, IL-6, and tumor necrosis factor-α are upregulated in hypertrophic tissues. Although many agents can be used to prevent postoperative adhesions, most of them are avoided due to side effects. However, corticosteroids and nonsteroidal anti-inflammatory drugs are often used during the postoperative period [11].

Although the relationship between hypertrophic scars and keloids and postoperative abdominal adhesions and their overlapping pathways have not been fully elucidated, Tulandi et al reported that patients with keloids at the wound site had more abdominal adhesions between the uterus and bladder and between the uterus and abdominal wall in repeated cesarean sections [12].

More severe pleural adhesions were observed in patients who had hypertrophic scar formation in the previous incision scar. This observation slightly influenced our clinical approach. Repeat operations were preferred to start with thoracoscopy, and if a problem occurred due to adhesions, then we switched to thoracotomy.

If hypertrophic scar formation is observed at the site of the previous incision in the physical examination of patients, preparations were increased for thoracotomy and the patient was informed about the higher possibility of open surgery. Although surgeries were started with minimal procedures on our patients with or without hypertrophic scar tissue, the conversion rate in open surgery was 2/6 in our patients with hypertrophic scar tissue, whereas this rate was 1/16 in those without hypertrophic scar tissue.

Our study is limited due to the low number of patients and being a retrospective evaluation. Another limitation is that keloids are more prone to occur in some races. However, our study population is not suitable for analyzing the effects of race on adhesions due to geographical reasons.

In conclusion, minimally invasive treatment should be started in patients with previous hypertrophic scar tissue. More caution should be taken in these patients in terms of informing the patients and their relatives preoperatively and preparations for the operating room and surgery. We believe that a prospective multicentric study should strengthen our hypothesis. Another factor that should be considered in a future prospective study is to classify the degree of scar formation and the amount of adhesions based on objective criteria.

Declaration of conflicting interests

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Ethics approval

This study was approved by the Kartal Lufu Kirdar Training Hospital Institutional Review Board (May 27, 2024, No: 2024/010.99/4/7).

Authors' contribution

CT; collected, analyzed and interpreted the patient data, CT,TC; conceptualized and designed the study, TC; wrote the paper, collected the literature data, TD; revised the final version of the manuscript, and co-wrote the paper. All authors read and approved the final manuscript.

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Original Article

Factors affecting mortality in esophageal perforation

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ABSTRACT

Background: Esophageal perforation have high mortality. Due to its relative rarity and lack of clinical experience, there are no established guidelines for its treatment. Abbas and colleagues developed a perforation severity score (PSS) in 2009, using the patient's clinical parameters at the time of diagnosis for predicting prognosis of the patient. We aimed to identify the prognostic factors affecting mortality for patients with esophageal perforation including PSS.

Materials and Methods: The records of 21 patients with esophageal perforation between 2010 and 2023 were examined retrospectively. The age, gender, Charlson Comorbidity Index, etiology, time to diagnosis, extent of perforation (contained/non-contained), localization, operation and PSS of the patients were recorded and their relationship with mortality was analyzed.

Results: Nine (42.9%) patients were female and the median age was 56 (19-73 years). Cervical perforations were seen in 13 (61.9%) patients and 8 (38.1%) patients had thoracic perforations. Median time to diagnosis was 2 days (1-30 days). Median PSS for non-operative patients was 2 and ıt was 6 for operative patients ($p = 0.086$). Mortality rate was 19% (4 patients). Patients are grouped according to mortality. Age, sex distribution, comorbidity index, etiology, perforation localization, time to diagnosis, management strategy and PSS between groups were compared. Only localization has statistically significant difference between groups ($p = 0.01$).

Conclusions: Optimum therapy should be chosen according to patients' comorbidities, etiology, perforation localization, extent of perforation, time to diagnosis and medical status of the patient. Patients with low-risk score and who have a contained leak could be treated with non-operative therapies

Keywords: esophageal perforation, perforation severity score, surgery, prognosis, mortality

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Introduction

Esophageal perforation is still a condition with high mortality despite advances in medicine and mortality rate rise up to 40% in past series [1]. The passage of gastric contents and oral intakes into the mediastinum and the mediastinitis it causes, followed by sepsis, is the main mechanism of death [2]. Today, iatrogenic perforations are in the first place among etiologies due to increasing number of diagnostic and therapeutic endoscopic procedures [3]. Diagnosis and treatment of esophageal perforation poses various difficulties for the clinician. Due to its relative rarity and lack of clinical experience, there are no established guidelines for its treatment. Treatment strategy mostly depends on the experience and judgement of the clinician. There are different therapeutic options including surgical and non-surgical interventions and also conservative approaches but yet there is no consensus on which treatment should be given to which patient. Abbas and colleagues developed a perforation severity score (PSS) in 2009, using the patient's clinical parameters at the time of diagnosis for this purpose [4]. There are some publications stating that this scoring system might be helpful for choosing ideal treatment and predicting patient outcomes [3,5,6].

In this study we aimed to identify the factors affecting mortality by examining the characteristics of the patients treated for esophageal perforation in our clinic and used the PSS as a prognostic factor.

Materials and Methods

The records of 21 patients treated in our clinic due to esophageal perforation between 2010 and 2023 were examined retrospectively. This study was approved by the Ankara University Institutional Review Board. Patients with tracheoesophageal fistula, leakage after esophageal surgery were excluded from the study. Diagnosis was made by endoscopy, computed tomography (CT) or esophagography with orally administered contrast media. The intervention decision and method were determined according to the surgeon's preferences. Three patients were treated with non-operative management (no oral intake, ıv antibiotics and parenteral nutrition) and others had surgical intervention. Surgical interventions included drainage only, primary repair and esophagectomy via cervical exploration, thoracotomy or laparotomy. Primary repair was tried ıf the perforation site was clear or with little contamination and with limited necrosis regardless of the time to diagnosis and reinforced with muscle flab's (strap muscles, sternocleidomastoid muscle, intercostal muscles) whenever possible. Esophagectomy was performed for three patients one with underlying esophageal carcinoma and the others with wide perforations and necrosis. Exploration and drainage was performed for patients unsuitable for primary repair. The age, gender, Charlson Comorbidity Index (CCI), etiology, time to diagnosis, extent of perforation (contained/non-contained), localization, operation and perforation severity scores (PSS) of the patients were recorded and their relationship with mortality was analyzed. Perforation severity score was calculated by scoring the patients' age, tachycardia, leukocytosis, pleural effusion status, fever, extent of perforation, respiratory distress, time until diagnosis, presence of cancer and hypotension separately and getting final score by adding them up (Table 1). Extent of perforation was evaluated with contrast enhanced esophagogram or CT scan with oral contrast and classified as non-contained or contained perforation. Non-contained perforation refers to free extravasation of contrast media to mediastinum, pleura or peritoneum and contained perforation was defined as minimal extravasation of contrast at the perforation site without pleural or peritoneal spillage. Mortality was defined as patients who died within 90 days after hospital admission or died in hospital.

Table 1. Perforation severity score (PSS) variable table.

Variable	Score
Age: > 75 years	1
Tachycardia: >100 bpm	1
Leukocytosis: >10 000 WBC/ml	1
Pleural effusion: present	1
Fever: >38.5oC	2
Extent of perforation: non-contained	2
Respiratory compromise: respiratory rate >30/min, increasing oxygen requirement, need mechanical ventilation	2
Time to diagnosis: >24 hours	2
Cancer: present	3
Hypotension: present	3

Abbrev.: Bpm: beat per minute, WBC/ml: White blood cell / milliliter. PSS adds up the scores of variables suitable for patient clinic at admission.

Statistical Analyses

The data obtained in the study was evaluated with the SPSS (Statistical Package for the Social Sciences) program version 23 for Windows. Descriptive data were presented in mean ± standard deviation (SD), median (min-max) or number and frequency where applicable. Mann Whitney U test or Student t-test was used to compare numerical variables of two independent groups. Chi-Square and Fisher Exact tests were used in the analysis of categorical variables. P value lower than 0.05 was accepted as statistically significant.

Results

Among 21 patients, 9 (42.9%) of them were female and the median age was 56 (19-73 years). Median CCI was 2 and only three patients had ≥4 score. Non-operative patients median CCI was 3 and for operative patients ıt was 1.5 (p = 0.12). While 9 patients had iatrogenic perforation (endoscopy, cervical spine surgery, esophageal intubation), 6 patients had perforation due to foreign body ingestion (chicken bone, meat bone, packaged medicine), 2 patients had spontaneous (one after vomiting [Boerhaave sydrome], one with chemoradiotherapy for laryngeal carcinoma), 1 patient had traumatic (gunshot wound) perforation and the cause of perforation could not be determined in 3 patients. Cervical perforations were seen in 13 (61.9%) patients and 8 (38.1%) patients had thoracic perforations. Median time to diagnosis was 2 days (1-30 days). Median PSS for non-operative patients was 2 and ıt was 6 for operative patients (p = 0.086). Non-operative management was preferred for 3 patients and all of them had cervical esophageal perforations. These patients comorbidity scores were 3, two of them had PSS 2 and only one patient's PSS was 6 due to laryngeal cancer. All three patients had contained perforations and were medically stable. They had no oral intake for at least ten days, ıv antibiotics were administered and waited for spontaneous healing. Ten patients with cervical perforations had operative management (%77) and 6 (46%) of them had primary repair. Only 2 of these patients underwent thoracotomy all the others had cervical exploration. All 8 patients with thoracic esophageal perforation had operative management. Three patients had emergency esophagectomy and 2 of them died in the early postoperative period. Three patients had left thoracotomy and primary esophageal repair. One of these patients needed esophageal stent at the same time with the operation because of the wide perforation area. One patient had right thoracotomy and drainage, one patient had drainage via laparotomy because of the severe emphysematous lungs. Patients had no oral intake at least 7 days and they had total parenteral nutrition. If the healing period exceeds over one week gastrostomy or jejunostomy routes were used for feeding. Six patients (28.5%) had never oral intake (4 patients died in the postoperative period, one patient died 3 months after the surgery and one patient had gastric perforation after the surgery and still followed with jejunostomy). Median time for oral intake resume was 14 days (7-365 days) (Table 2).

Mortality rate was 19% (4 patients). Patients are grouped according to mortality and age, sex distribution, comorbidity index, etiology, perforation localization, time to diagnosis, management strategy and PSS between groups were compared. Only localization has statistically significant difference between groups (p = 0.01) (Table 3).

Discussion

Iatrogenic perforations are leading etiology for esophageal perforation nowadays and also in our study 42.8% of patients had iatrogenic perforations due to endoscopy, cervical spine surgery or esophageal intubation [1-4]. In the study of Eroğlu et al 36 esophageal perforations occurred between 1989 and 2002 was reviewed. Although ıt represents an earlier timeline, again most of the patients had iatrogenic perforations (63.9%) [7].

Studies from America, Europe, Norway and Germany gives rates of late time to diagnosis (>24 hours) between 24.6% and 50% [1,5,6,8,9,]. Our late time to diagnosis rate is 38% and comparable with worldwide. In a meta-analysis published by Vermeulen et al [10] including 25 studies and 960 patients with esophageal perforation, early diagnosis (≤24 hours) was associated with only a 6% decrease in overall mortality. Also in our study there was no difference in mortality rates between early and late diagnosis. This may be interpreted as time to diagnosis is not strong enough to determine the patient prognosis.

Table 2. Patient list with important clinical characteristics.

Patient no	Etiology	Localization	Time to diagnosis (days)	Management	PSS	Mortality
1	Iatrogenic	Cervical	1	Non-operative	6	0
2	Iatrogenic	Cervical	5	Cervical exploration+drainage	7	0
3	Spontaneous	Thoracic	1	Left thoracotomy+primary repair	11	0
4	Traumatic	Thoracic	1	Esophagectomy	3	1
5	Unknown	Cervical	7	Cervical exploration+drainage	7	0
6	Spontaneous	Cervical	7	Right thoracotomy+drainage	16	0
7	Foreign body	Thoracic	2	Laparatomy+drainage	13	1
8	Iatrogenic	Cervical	4	Cervical exploration+drainage	8	0
9	Iatrogenic	Cervical	1	Cervical exploration+primary repair	2	0
10	Iatrogenic	Cervical	30	Cervical exploration+primary repair	4	0
11	Unknown	Cervical	2	Non-operative	2	0
12	Foreign body	Thoracic	1	Left thoracotomy+primary repair+stent	4	1
13	Foreign body	Thoracic	1	Left thoracotomy+primary repair	3	0
14	Iatrogenic	Cervical	2	Cervical exploration+primary repair	5	0
15	Iatrogenic	Cervical	12	Cervical exploration+primary repair	4	0
16	Foreign body	Cervical	1	Cervical exploration+primary repair	6	0
17	Iatrogenic	Cervical	1	Right thoracotomy+cervical exploration+primary repair	5	0
18	Foreign body	Thoracic	4	Right thoracotomy+drainage	6	0
19	Iatrogenic	Thoracic	2	Esophagectomy	15	1
20	Unknown	Thoracic	7	Esophagectomy	13	0
21	Foreign body	Cervical	4	Non-operative	2	0

Abbrev.; PSS: perforation severity score

Table 3. Analysis between patient characteristics and mortality.

Variables, n (%)	Alive: 17 (81)	Exitus: 4 (19)	p
Age (mean±SD)	52.6±13	58.6±17	0.47
Sex			1
Female	7 (41.2)	2 (50)	
Male	10 (58.8)	2 (50)	
CCI (median)	2	3	0.33
Etiology			0.60
İatrogenic	8 (47.1)	1 (25)	
Others	9 (52.9)	3 (75)	
Localization			0.01
Cervical	13 (76.5)	0	
Thoracic	4 (23.5)	4 (100)	
Time to diagnosis			0.62
≤24 h	6 (35.3)	2 (50)	
>24 h	11 (64.7)	2 (50)	
Management			1
Non-operative	3 (17.6)	0	
Operative	14 (82.4)	4 (100)	
PSS (median)	6	8.5	0.59

Abbrev.; CCI: Charlson comorbidity index, PSS: perforation severity score

In the published series of esophageal perforation the rate of surgical interventions as first line treatment is given between 47%-77% [1,3-7,10,11]. Surgical therapies include primary repair, drainage only, or esophagectomy mostly. Nowadays endoscopic stenting and other endoscopic modalities have an increasing trend over surgery. In the study of Gray et al [12] with 2543 esophageal perforations, 48.3% of the patients had stents for treatment

and stenting increased from 7.0% in 2009 to 78.1% in 2019. In our series only one patient had stent at the same time with surgery because of wide perforation area.

Management strategies differs from center to center, patient to patient as there are no clear guidelines. Optimum therapy should be chosen according to patients' comorbidities, etiology, perforation localization, extent of perforation, time to diagnosis and medical status of the patient. Abbas et al [4] proposed a perforation severity score (PSS) to guide selecting patients for operative or non-operative management. PSS ≤ 2 low-risk, PSS 3-5 intermediate-risk and PSS > 5 is estimated to be related with high-risk groups. In our study there was no mortality in low-risk group and median PSS was higher for patients with mortality although statistically not significant (8.5 / 6, p = 0.59 respectively). Patients with low-risk score and who have a contained leak could be treated with non-operative therapies. High-risk group should be treated with aggressive management because mortality rates are high. İntermediate risk group can be treated with individualized therapies based on underlying etiology, comorbidities, localization and extent of perforation. No patient with cervical perforation died in our cohort. Our mortality rate is 19% and it is comparable with the literature (13%-23.4%) [1-8].

Cervical perforations have low mortality risk so they can be managed as low-risk group [6]. Comorbidity scores of patients and underlying esophageal pathologies could be included in the PSS because these factors directly influence the operative management strategies. [5].

In conclusion, as this is a retrospective study with limited number of patients and also patients were not treated according to PSS or any other guideline, the results should be interpreted carefully. It can give an idea of treatment strategies for a rare and urgent clinical situation.

Declaration of conflicting interests

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Ethics approval

This study was approved by the Ankara University, Institutional Review Board (2024/279, No: I03-286-24)).

Authors' contribution

GK: conceptualized and designed the study, collected, analyzed and interpreted the data, wrote the paper, YK: collected the data, reviewed the literature, MÖ: revised the final version of the manuscript, and co-wrote the paper, BY: revised the final version of the manuscript. All authors read and approved the final manuscript.

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Original Article

Do atmospheric pressure and air pollution affect the incidence of primary spontaneous pneumothorax?

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ABSTRACT

Background: Primary spontaneous pneumothorax (PSP) occurs as a result of rupture of bullae or blebs adjacent to the visceral pleura. In our study, we retrospectively reviewed the weather information of PSP patients admitted to our clinic and aimed to investigate the relationship between meteorological changes and the development of PSP.

Materials and Methods: A total of 5051 patients were included in the study. Weather records between January 2020 and March 2023 were recorded day by day. The data obtained from Istanbul Regional Meteorological Measurement Center, Fatih Air Monitoring Center, and Atatürk Airport Air Monitoring Center within the provincial borders were recorded and accepted as the daily weather data of the city.

Results: NO2 and PM10 were shown to have a significant effect on the risk of pneumothorax. Curve estimation regression analysis showed that the mean NO2 level for Istanbul was 50 ± 12.4 picograms/m^3, and a significant increase ($p = 0.035$) in the risk of pneumothorax occurred when the level reached 30 picograms/m^3. PM10 concentrations above this value significantly increased the risk of pneumothorax, and this increase was statistically significant ($p = 0.018$).

Conclusions: In our study, the frequency of pneumothorax increased significantly as the concentration of NO2 and P10 particles in the air increased. This indicates that the risk of pneumothorax increases with the increase in particulate matter in air pollution. This highlights the importance of environmental factors on health and the need to improve air quality, which may be important in developing public health policies and prevention strategies.

Keywords: primary spontaneous pneumothorax, microparticle number, nitrogen dioxide, meteorological conditions

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Introduction

Primary spontaneous pneumothorax (PSP) occurs as a result of rupture of bullae or blebs adjacent to the visceral pleura. Poor body type, smoking, and young age are among the most commonly accepted risk factors [1-3]. There is no consensus on other factors associated with PSP formation. Many studies have investigated the role of meteorological conditions, air pollutants, and weather events in the development of PSP [2-7].

In this study; we aimed to analyze the relationship between weather conditions and pneumothorax occurrence in patients without pulmonary parenchymal disease. Therefore, we retrospectively reviewed the weather information of PSP patients admitted to our clinic and investigated the relationship between meteorological changes and the development of PSP.

Materials and Methods

Patients admitted to the emergency department/polyclinic of Yedikule Chest Disease and Thoracic Surgery Thoracic Surgery Training and Research Hospital between January 2020 and March 2023 were reviewed retrospectively. Patients with code J93 (pneumothorax) in the ICD-10 coding system were screened in the patient tracking system (n = 8173). Patients with secondary spontaneous pneumothorax, traumatic pneumothorax, iatrogenic pneumothorax, and 3122 patients with insufficient data in the registry system were excluded from the study. None of the included patients have pulmonary parenchymal disease. A total of 5051 patients were included in the study.

Weather records between January 2020 and March 2023 were recorded day by day from the official websites www.havaizleme.gov.tr and mgm.gov.tr/site/urunler.aspx of the Ministry of Environment, Urbanization, and Climate Change. The data obtained from Istanbul Regional Meteorological Measurement Center, Fatih Air Monitoring Center, and Atatürk Airport Air Monitoring Center within the provincial borders were recorded and accepted as the daily weather data of the city. The recorded data were mean air pressure (hPa), PM10 (microparticle number) (μg/m3), SO2 (sulfur dioxide) (μg/m3), CO (carbon monoxide) (μg/m3), NO2 (nitrogen dioxide) (μg/m3), NOX (nitrogen gas derivatives) (μg/m3), NO (nitrogen monoxide) (μg/m3).

In the study, the relationship between the patients diagnosed with pneumothorax for each day and the weather data and mean air pressure on the same day was investigated. The study was conducted in accordance with the principles of the Declaration of Helsinki. This study was approved by Health Sciences University Ethics Committee no: 2023-435.

Statistical Analyses

SPSS 26.0 for Windows program was used for statistical analysis. Descriptive statistics were given as numbers and percentages for categorical variables and mean, standard deviation, minimum, maximum, and median for numerical variables. Curve estimation regression analysis was performed to find the daily incidence of PSP and the safety interval of each parameter in terms of pneumothorax risk. P value lower than 0.05 was accepted as statistically significant.

Results

In the demographic evaluation of 5051 patients included in the study, 81.12% (n = 4097) were male, 18.88% (n = 954) were female, and the mean age was 26.56 years (min: 13, max: 68).

Among the meteorological data analyzed, especially NO2 and PM10 were shown to have a significant effect on the risk of pneumothorax. Curve estimation regression analysis showed that the mean NO2 level for Istanbul was 50 ± 12.4 picograms/m^3, and a significant increase ($p = 0.035$) in the risk of pneumothorax occurred when the level reached 30 picograms/m^3 (Table 1).

It was determined that PM10 concentrations above 10 picogram/m^3 caused an increase in the risk of pneumothorax, and the threshold value for PM10 was 30 picogram/m^3. PM10 concentrations above this value significantly increased the risk of pneumothorax, and this increase was statistically significant ($p = 0.018$) (Table 2).

Besides, the mean values of other meteorological parameters such as SO2, NO, NOX, and CO were 55 ± 13.2, 50.99 ± 12.7, 85.36 ± 22.2, 679.99 ± 165.2 30 picograms/m^3, respectively, however, no significant correlation was found between these variables and the incidence of pneumothorax. These findings reveal that especially NO2 and PM10 have the strongest relationship with the risk of pneumothorax among air pollution parameters.

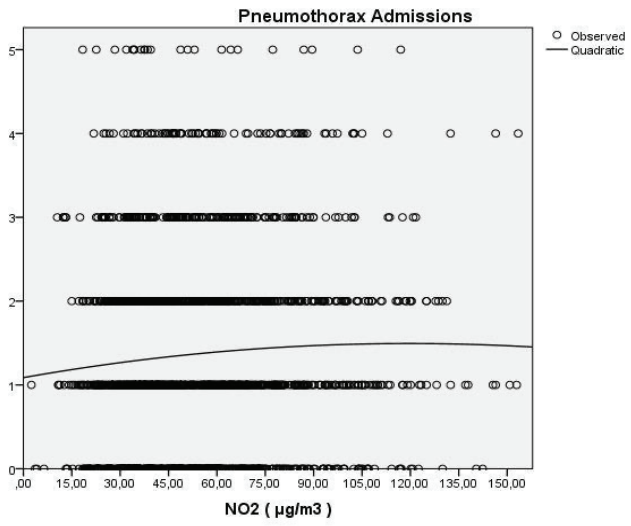

Table 1. There is a significant increase in the incidence of pneumothorax with increasing NO2 (p = 0.035).

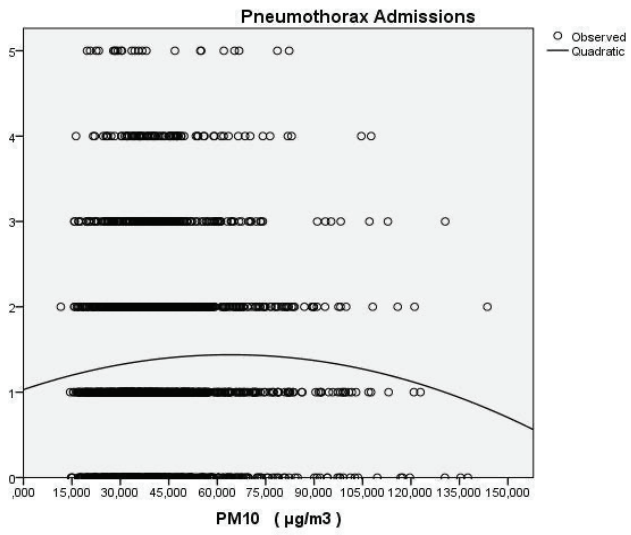

Table 2. The incidence of pneumothorax increases with the increase in PM10, and it is seen to be a risk factor for PSP, especially after 30 (p = 0.018).

Discussion

Primary spontaneous pneumothorax (PSP) develops as a result of rupture of bullae or blebs adjacent to the visceral pleura. A thin body type, smoking, and young age are among the most commonly accepted risk factors [1]. There is no consensus on other factors associated with PSP formation.

Many studies have investigated the role of meteorological conditions, air pollutants, and weather events in the development of PSP. Air pollutants are a mixture of chemical species from various sources, and some may also be produced through atmospheric photochemical processes. The respiratory system is more affected by air pollution than other organs in the human body due to its direct contact with air [2-4]. Small-sized air pollutants pass through small airways into the alveoli and cause activation of pro-inflammatory mediators [5,6]. This then causes systemic autonomic imbalance, leading to sudden cardiac arrest as well as exacerbation of respiratory diseases such as asthma, chronic obstructive pulmonary disease, and pneumothorax [6]. Air temperature and atmospheric pressure (AP) have been the most frequently reported meteorological factors affecting the occurrence of PSP [5-8].

In this study, it was revealed that NO2 reaching a level of 30 picograms/m3 significantly increased the risk of pneumothorax. For PM10, a mean level of 10 picograms/m^3 was found to start the risk of pneumothorax, and 30 picograms/m3 was found to increase the risk of PSP statistically significantly. In conclusion, NO2 and PM10 values were found to be associated with the incidence of primary spontaneous pneumothorax (PSP). Our findings suggest that certain air pollutants may be a potential increased risk factor for pneumothorax. These results are partially consistent with but differ from, a large number of studies focusing on this issue worldwide. Several studies in the literature have reported varying associations between air pollutants and meteorological data, such as air pressure changes, wind speed, temperature, and PSP, emphasizing the complexity of the health effects of environmental factors.

A retrospective analysis conducted by Bartolaccini et al in Turin, Italy, showed that short-term NO2 exposure may increase the risk of PSP [9]. Another study conducted in Seoul, South Korea, showed that O3, NO2, PM10, and sudden pressure changes increased the risk of PSP [1]. In the literature, there are studies presenting similar findings that NO2 increases the risk of PSP [10-11]. The number of studies investigating the relationship between PM10 level and PSP is less and statistically significant results were obtained in the existing publications [10-13]. However, there are also literature data in which no relationship between NO2 and PM10 and PSP was found [10]. In our study, an increase in NO2 and PM10 levels was associated with an increase in the incidence of PSP.

Meteorological factors, especially air temperature and atmospheric pressure changes, are among the impor-

tant factors in the formation of primary spontaneous pneumothorax (PSP). In particular, sudden atmospheric changes may pave the way for PSP formation by bringing risks such as rupture of alveoli or bullae/bleb walls. Some theories suggest that repetitive pressure changes may lead to weakening and subsequent rupture of these structures [14,15]. Furthermore, by a mechanism similar to asthma, air may be trapped in bullae or blebs by a check valve mechanism as a result of rapid pressure gradient changes, which has also been associated with PSP [14]. Many studies have shown that abnormal changes in atmospheric pressure (AP), together with other meteorological factors such as temperature, humidity, wind speed, and storms, may increase the risk of pneumothorax. For example, Bense et al [16] reported a significant increase in the number of PSP patients within two days following a 10 hPa decrease in AP within 24 hours. Scott et al [17] examined 192 cases of PSP with abnormal changes in AP four days before the PSP increase and found that 72% of cases had an increased risk of PSP after exposure to sudden pressure change. In a study of 337 PSP patients over three years, a statistically significant correlation was found between low AP and increased risk of PSP [10]. However, these associations have not been consistently reported in all studies, with some studies showing no specific relationship between AP and the development of pneumothorax [15,18]. In summary, there are various findings on the impact of atmospheric pressure and air temperature changes on the occurrence of PSP, but these effects are still not fully understood. In our study, air temperature data were not included, and no significant relationship was found between air pressure and the incidence of PSP.

Many studies have found a statistically significant increase in the number of pneumothorax cases on certain days and focused on clusters in the number of cases. In an analysis of 115 patients over two years, clusters in pneumothorax admissions were examined, and 73% were found to be included in clusters [4]. In an analysis of 294 PSP cases over four years in Italy, 86% of patients showed clustering and atmospheric pressure difference, which was found to be associated with PSP [10]. There are studies indicating that the difference between the pressures of the days when only PSP was detected and the previous days is a significant predisposing factor [19]. Özpolat et al [20] analyzed 669 patients admitted within ten years. Days with spontaneous pneumothorax were clustered, and reported that low AP was associated with an increased risk of PSP.

In all of these studies, clustering required either a relatively small number of patients or a longer period of time. Since PSP cases were admitted to our hospital on almost all of the dates included in the study, clustering could not be established. Similar to studies using clustering, a significant association with AP was not detected in our study, however, a significant association between PM10 and NO2 and PSP was revealed.

In another study examining the relationship between air pollutants and pneumothorax, Abul et al [19] reported that spontaneous pneumothorax was observed more frequently at high ozone levels. In some studies, the relationship was not revealed, and statistically significant results could not be reached [10]. When the relationship between SO2 CO and PSP is examined, the number of studies with statistically significant results in this regard is even lower [10-13]. In our study, no statistically significant relationship was found between O3, SO2, and CO levels and the incidence of PSP.

Although there are some controversies, seasons and weather changes are also reported to be risk factors in the occurrence of PSP. Numerous studies have reported that seasonal and weather changes are important factors associated with increased incidence of PSP [10,21,22]. Factors such as temperature and wind may also contribute to seasonal factors. Increased wind speed may lead to bronchiolar spasms, mucus retention, and coughing by directly carrying air pollutants [21]. This mechanism may increase the risk of bubble or bullae rupture. In our study, no significant relationship was found between the incidence of PSP and seasons. In addition, wind and long-term temperature monitoring data were not included in our study due to lack of data.

The differences in the above-mentioned results point to the role of study design, climate, and the demographic conditions in which the study was conducted.

Our study revealed that an increase in NO2 and PM10 significantly increased the risk of PSP. This finding sup-

ports our preliminary thesis that an increase in air pollutants may increase the risk of PSP.

The main limitation of this study is its retrospective, single-center design and the fact that patients were not admitted to the hospital on the days of onset of clinical symptoms, which makes these analyses based on diary data misleading. This study include the inability to distinguish the effects of other environmental and personal factors fully. Furthermore, the influence of other variables that may affect the association between air pollution and PSP (e.g., air temperature, humidity) was not examined in detail in this study

However, it also has several important strengths. Firstly, the data were recorded in one of the most populous cities in the world, and secondly, accurate meteorological data were obtained from the national meteorological agency. This study suggests that air pollution may have a significant impact on the risk of pneumothorax. Thus, our study has important clinical and epidemiologic information to guide air pollution levels and to advise patients at high risk of vulnerable PSP (poor body type, smoking, and young age) on the need to stay indoors when air quality is poor. This result is particularly important for emergency departments because it shows that the possibility of primary spontaneous pneumothorax should be considered among the priority diagnoses on days when NO2 and PM10 levels increase in atmospheric measurements.

In conclusion, this study is based on a large series of patients and includes a wide range of geographical and epidemiologic data since it was conducted in one of the largest cities in the world. These features provide an important advantage in terms of the generalizability of our results. Furthermore, comparing the results of our study with studies from various geographical regions and different air quality conditions allows a global perspective to be gained. The frequency of pneumothorax increased significantly as the concentration of NO2 and P10 particles in the air increased. This indicates that the risk of pneumothorax increases with the increase in particulate matter in air pollution, highlighting the importance of environmental factors on health and the need to improve air quality, which may be important in developing public health policies and prevention strategies. Future research may further elucidate the relationship between air pollution and pneumothorax, contributing to the development of interventions to reduce this health risk.

Declaration of conflicting interests

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Ethics approval

This study was approved by Health Sciences University Ethics Committee no: 2023-435.

Authors' contribution

AC; designed the analysis, wrote the paper, ME; collected data, performed the analysis, YS; collected data, AMA; collected data, NC; contributed data, LC, MAB; editing.

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Original Article

Air leak grading in primary spontaneous pneumothorax is useful to predict prolonged air leak

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ABSTRACT

Background: Results of studies to predict prolonged air leak (PAL) after chest tube administration in primary spontaneous pneumothorax (PSP) have been inconsistent and have limited use. In this study, in which we used a scale grading the amount of air leak, we investigated the correlation between the scale and the duration of air leak and its potential to be a predictor of PAL.

Materials and Methods: PSP cases (n = 140) requiring chest tube insertion between April 2017 and December 2021 were prospectively studied. We graded the air leak in these patients using a 5-grade scale. We designed eight 'SUM' variants using air leak grades within the first five days after chest tube administration. In this study, PAL was defined as an air leak lasting more than five days.

Results: Total PAL occurrence was 29 (20.7%) in this cohort with a mean age of 26.6±8.14 years. Correlation analyses showed that each SUM variable correlated highly with the duration of the air leak, and SUM7to8, the sum of two consecutive values of air leak grades on the fourth day, was proved to be the most powerful predictor. When SUM7to8 ≥ 1, PAL can be predicted with a positive and negative predictive value of 69% and 100%, respectively. The sensitivity and specificity are 100% and 88.3%, respectively.

Conclusions: This simple new method of predicting PAL using SUM7to8 has shown that the amount of air leak is a powerful independent predictor of PAL. Therefore, grading air leakage in PSP is a useful method to predict PAL.

Keywords: prolonged air leak, primary spontaneous pneumothorax, air leak grade, chest tubes

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Introduction

Primary spontaneous pneumothorax (PSP) is defined as the abnormal accumulation of air in the pleural space without apparent underlying lung disease. The global incidence is 7.4 -18/1,000,000 men and 1.2 - 6/1,000,000 women per year [1]. It is usually observed in young adults who are tall and thin, and who smoke. PSP has a high recurrence rate that goes up to 55% with conservative treatment [2]. Treatment methods have been discussed many times from past to present. Treatment may vary from only monitoring the patient to performing an operation in the first pneumothorax attack. Although most pneumothorax cases can be resolved with a chest tube, some of them persist even days later. The duration of persistent air leak (PAL) and the timing of surgery are not clear. It is generally called PAL if the air leak after chest tube insertion lasts more than 5 or 7 days. PAL requires further surgical treatment as it increases other pulmonary risks such as pneumonia and empyema [3,4]. PAL is usually caused by spontaneous pneumothorax arising from underlying lung disease (secondary spontaneous pneumothorax), pulmonary infections, and complications of mechanical ventilation, chest trauma, or pulmonary surgery [4]. In PSP, air leakage is mostly expected to cease in a shorter time. Should we also wait for 5-7 days in PSP to decide on surgery, or can the grade of air bubbling observed with chest tube drainage be a guide to deciding earlier? The results of previous studies to predict PAL have been inconsistent and have limited use. In this study, we investigated the importance of the air leak grading scale, used by Oh et al [5] to predict PAL following pulmonary lobectomy, in predicting PAL in patients who underwent chest tube insertion due to PSP.

Materials and Methods

A total of 585 pneumothorax patients were admitted to our hospital between April 2017 and December 2021 and were treated by the same surgical team. Of these patients, 445 were excluded from the study. The data of 140 patients who underwent chest tube insertion after being diagnosed with PSP and met the study inclusion criteria were prospectively collected by the researchers.

Exclusion criteria were underlying lung disease (e.g., malignancy, interstitial lung disease, chronic obstructive pulmonary disease), traumatic or iatrogenic pneumothorax, age over 50 years, surgery within the first 72 hours due to ipsilateral or contralateral recurrence or bilateral pneumothorax despite chest tube insertion (even though there is no air drainage after chest tube administration, the presence of patients who underwent early surgical treatment does not overlap with the main objective of the study), recurrence (even though the same patient underwent a second chest tube insertion for recurrence during the study period, only the first chest tube administration was included in the study), re-administration of chest tube due to recurrence in the early postoperative period following treatment with VATS.

To diagnose PSP, we used chest radiography, the most common and accessible method. We preferred computed tomography to examine the lung parenchyma in terms of etiology after an emergency intervention, mainly with a chest tube.

For the treatment, a single 28 French (Fr) chest tube was used in all 140 patients under local anesthesia. A skin incision of approximately 15 mm width was usually performed at the intersection of the fifth or sixth intercostal space and the mid-axillary line. Using curved Metzenbaum scissors, the subcutaneous tissues and intercostal muscles were dissected, making a tunnel to the pleural space. After the tunnel was created, drain fixation suture was placed into both corners of the skin incision with atraumatic sharp number 1 silk suture. During chest tube removal, to close the incision, another suture was placed in the middle of the incision, the ends of which were left unknotted. With the help of a clamp, a chest tube was inserted into the chest cavity and advanced towards the apex. After air drainage was observed in the closed underwater drainage system, the tube was fixed to the patient's skin using fixation sutures. The suture in the middle was left unknotted and wrapped around the drain. The procedure was terminated by dressing the wound. Suction was not applied to closed underwater drainage in any of the patients. This study was approved by the designated Ethics Committee of our hospital. The approval number is 49109414-604.02-7018.

Air leak grading and definition of 'P' time period

In the days following chest tube administration, the semi-quantitative evaluation of air leakage was scored using a 5-grade scale (Table 1) every 12 hours, morning and evening periodically (P), for five days. Air leak grading based on the evaluation of volitional coughing by the patient was performed by the residents. To facilitate data collection, each visit period was defined as a 'P' time scale, and the visit periods were expressed as P1, P2, P3, P4, etc., respectively (Table 2).

Table 1. Air leak grading.

Grade	Definition
0	No air bubbles on cough
1	Only a few air bubbles on cough
2	Persistent air bubbles on cough
3	Persistent, small amount of air bubbles on spontaneous respiration
4	Persistent, large amount of air bubbles on spontaneous respiration

Definition of PAL

We did not remove the chest tube until air drainage had stopped completely in the previous 24 hours. The cessation of air leakage was defined as the degree of air leakage being 0 points for at least two periods. In this study, PAL was defined as an air leak lasting longer than 5 days (>10 P).

"SUM" variables as predictors of PAL

For semi-quantitative comparison of air leakage following chest tube administration, we designed eight "SUM" variables, where we evaluated the degree of air leakage from P1 to P10 (Table 2). We studied the eight SUM variables, respectively, representing the amount of air leak to find out whether they were associated with PAL. The most appropriate variable among the variables that correlate with PAL and the threshold value for PAL prediction were obtained. We tested other predictors derived from variables such as age, gender, pneumothorax side, smoking, and pneumothorax recurrence to see if they had any additional effect on optimizing the PAL prediction.

Statistical Analysis

Pearson's $\chi 2$ test analysis was performed by creating crosstabs for the comparison of categorical variables between PAL (+) and PAL (-).Student's t-test analysis was performed for numerical variables. Categorical data were presented as numbers and percentages. Numerical variables were summarized as mean ± SD and median (min – max). Eight variations, SUM1to2, SUM3to4, SUM5to6, SUM7to8, SUM1to4, SUM3to6, SUM1to6, SUM1to8, were created for daily air leak scores. Receiver operating characteristic (ROC) curve analysis was performed for each variation of PAL status, and the areas under the ROC curve (AUC) were compared to select the best predictive SUM variable. In ROC analyses, the cutoff was calculated according to the Youden index. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were determined according to the calculated cutoff values. The statistical significance level was determined as $p < 0.05$. Statistical tests were performed using SPSS software (IBM SPSS Statistics Version 25, IBM Corporation, Armonk, NT, United States).

Results

One hundred and forty patients with a mean age of 26.6 ± 8.14 were included in the study. One hundred twenty-eight of the cases (91.4%) were male. Pneumothorax was on the right in 81 (57.9%) patients and on the left in 59 (42.1%) patients. Of the patients, 123 (87.9%) had a first pneumothorax attack, 14 (10%) had a second, and 3 (2.1%) had a third attack. Five (29.4%) of the recurrences were contralateral. According to the leukocyte values measured on the first day after the drain was inserted, 66 (47.1%) patients had leukocytosis. The mean time the chest tubes were in place was 4.3 ± 2.6 (2-17) days. The median leak score was recorded as 2.0 (0-39). Total

Table 2. Definitions of 8 "SUM" variable.

Days[a]	1		2		3		4		5	
Periods[b]	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Air leak grade[c]	0-4 (n1)	0-4 (n2)	0-4 (n3)	0-4 (n4)	0-4 (n5)	0-4 (n6)	0-4 (n7)	0-4 (n8)	0-4 (n9)	0-4 (n10)
Variables	Definitions									
SUM^{1to2}	n1 + n2									
SUM^{3to4}	n3 + n4									
$SUM5^{to6}$	n5 + n6									
SUM^{7to8}	n7 + n8									
SUM^{1to4}	n1 + n2 + n3 + n4									
SUM^{3to6}	n3 + n4 + n5 + n6									
SUM^{1to6}	n1 + n2 + n3 + n4 + n5 + n6									
SUM^{1to8}	n1 + n2 + n3 + n4 + n5 + n6 + n7 + n8									

[a] Days after chest tube insertion; [b] morning and evening visit periods (P); [c] 'n' represents the air leak grade, from 0 to 4.

PAL occurrence in this cohort was 29 (20.7%). Thirty-four (24.3%) patients underwent video-assisted thoracoscopic surgery (VATS) for PAL and other indications. Three patients who could not be operated on for PAL due to various reasons were discharged by switching to the Heimlich valve system. Wedge resection and apical pleurectomy were performed via VATS in the other 26 patients with PAL.

Univariate analysis did not reveal a significant difference between PAL (+) and PAL (-) in terms of age, gender, pneumothorax side, leukocytosis at the time of diagnosis, smoking, and recurrent pneumothorax (Table 3).

Based on the 140 patients who were treated with a chest tube, correlation analyses showed that each SUM variable was strongly associated with PAL. In the analysis of the SUM variables (SUM1to4) of the first two days following the chest tube insertion, according to the Youden index, the cutoff for total air drainage score was regarded as ≥ 4, while it was ≥ 5 in the analysis of the SUM variables (SUM1to6) of the first three days, and ≥ 6 for the SUM variables (SUM1to8) of the first four days. The cutoff was calculated as ≥ 4 when the SUM variables (SUM3to6) of only the second and third day were considered. In all day-based evaluations, the cut-off was calculated as ≥ 1. ROC curves were generated for the SUM variables (Figure 1). In the ROC analyses, the AUC value ranged from the lowest of 75.8% for SUM1to2 to the highest of 94.1% for SUM7to8 (Table 4). The calculated AUC revealed that SUM7to8 was the most powerful predictor of PAL, and when SUM7to8 ≥ 1, PAL could be predicted with 100% sensitivity and 88.3% specificity, with 69% PPV and 100% NPV.

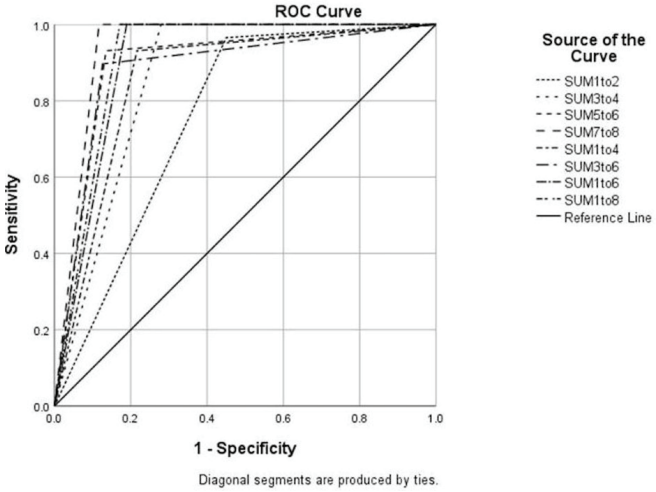

Figure 1. Comparison of the SUM variables. The dashed line represents the ROC curve, the highest AUC derived from only SUM7to8.

Table 3. Baseline characteristics and results of univariable analyses.

Variables	No. of cases (%)			P value[a]
	All (n=140)	PAL (-)(n=111)	PAL (+) (n=29)	
Ageb (years)	26.6±8.1	26.2±7.9	28.1±8.8	0.28c
Male	128 (91.4%)	103 (92.8%)	25 (86.2%)	0.25
Right side	81 (57.9%)	64 (57.7%)	17 (58.6%)	0.92
Leukocyte (>103)	66 (47.1%)	54 (48.6%)	12 (41.4%)	0.48
Smoker	106 (75.7%)	85 (77.3%)	21 (72.4)	0.58
Recurrent pneumothorax	18 (12.9%)	15 (13.5%)	3 (10.3%)	0.65

[a]P values are for comparison between PAL (-) and PAL (+), [b] Exceptionally, ages are expressed as "mean±SD" , [c] Student's t-test was performed. In other cases, Pearson's χ^2 test was performed.

Table 4. Statistical values of SUM variables.

c	Calculated AUCa (%)	Sensitivity (%)	Specificity (%)	PPVb (%)	NPVc (%)
SUM_{1TO2}	75.8	96.6	55	35.9	98.4
SUM_{3to4}	86	100	72	48.3	100
SUM_{5to6}	89.8	93.1	86.5	64.3	98
SUM_{7to8}	94.1	100	88.3	69	100
SUM_{1to4}	85.7	93.1	78.4	52.9	97.8
SUM_{3to6}	88.5	89.7	87.4	65	97
SUM_{1to6}	90.5	100	81	58	100
SUM_{1to8}	91.4	100	82	60.4	100

[a]AUC denotes area under the ROC curve, [b]PPV, positive predictive value, [c]NPV, negative predictive value, the bold data show that SUM-7to8 is the most powerful predictor of PAL (i.e. the largest AUC).

Discussion

PAL is one of the most common problems in thoracic surgery and a significant cause of morbidity. It suggests that the fistula on the pleural surface is large, and the probability of spontaneous closure of the fistula is low. It causes failure of lung re-expansion in most patients and requires more advanced surgical methods. Prediction of PAL and early surgical intervention reduce morbidity and shorten hospital stay. We thought that the amount and duration of air leak could be a marker for PAL in patients with PSP who had required chest tube treatment. In a conventional closed underwater drainage system, we tracked the amount of leakage using an observational grading method.

There is no clear consensus on the definition of PAL, and it usually defines leakage that lasts more than 5-7 days [3,4]. In a report, the median time for spontaneous cessation of air leak was 7 days for primary spontaneous pneumothorax and 11 days for secondary spontaneous pneumothorax [6]. Since the underlying cause is different in primary and secondary pneumothorax, the duration of PAL and the surgical approach may differ in these two entities. While treatment with a chest tube can continue for a longer time and conservative methods and pleurodesis can be applied in secondary spontaneous pneumothorax, the next step after chest tube insertion is mostly a surgical treatment with VATS in PSP patients. However, the optimum time for surgical intervention remains unclear. Considering this situation, we decided to analyze only those who underwent chest tube insertion for PSP when planning our study. In this way, we thought we could conduct a more specific study for PAL in patients with similar primary lung pathology.

Although there are many studies on predicting PAL, most of them are retrospective analyses with heterogeneous patient groups that aim to identify predictive risk factors by comparing PAL groups with other groups. In addition, since there is no consensus on the duration of PAL, each study has discussed this period differently. On the other hand, our study includes a homogeneous population of selected patients treated with a chest tube for PSP, and it is based on a prospectively collected single-center database. Other studies have reported various risk factors, such as interpleural distance, pneumothorax size, time from symptom onset to hospital admission, poor lung function, and malnutrition, as predictors of PAL [1,2,5]. However, study results are mostly inconsistent and have limited clinical utility. With the semi-quantitative tracking of the amount of air leak in patients who had chest tube insertion, the prediction of PAL is much more practical and significant compared to other studies.

Patients who have undergone chest tube insertion and have not achieved the desired result due to PAL are easily treated with VATS in a short operating time. Considering that PSP is a disease with a high probability of recurrence and VATS is an extremely comfortable surgical method for the patient, it is of great significance to identify patients, who will be operated on for PAL, in less than 5-7 days. There will be, thus, some advantages such as shorter hospital stay, lower risk of pleural and parenchymal infection, and shorter chest tube duration.

In recent years, studies have been carried out using digital measuring devices to predict the probability of failure of chest tube treatment [7,8]. However, these studies have been conducted with a much smaller number of patients when compared to our study and consist of comparisons of heterogeneous patient groups. Furthermore, these devices are not widely used in daily practice and bring additional costs. However, as in our study, visual assessment of the size of the air leak does not require any special techniques, extra financial costs, or time. Moreover, the sensitivity, specificity, PPV, or NPV rates obtained with these studies are lower than in this study. Therefore, the scales based on air bubbles observed in the closed underwater drainage bottle after the patient's respiratory movements and coughing are much more practical and meaningful. In the past, such studies had been performed to identify PAL after lobectomy (5,9,10). There are several classifications aiming to quantify the severity of PAL in the postoperative setting, including the most cited classification by Cerfolio [9], which grades PAL according to whether the leak is expiratory or continuous and the amount of air leak. One of these is the 5-grade scale in which Oh et al [5] grade postoperative air leak after pulmonary lobectomy (Table 1). In our study, we preferred using this scale, which is very practical. Due to its potential to be a predictor of PAL in PSP patients, we used the scale prospectively, which Oh et al [5] used retrospectively for pulmonary lobectomy.

Studies define PAL differently and analyze heterogeneous patient groups. The overall incidence of PAL is therefore unknown [11]. The incidence of PAL after lobectomy ranges from 5.6% to 26% in various reports [5,12-16]. In the study where Chee et al [17] determined

PAL as 7 days, the rate of PAL was 25% in 31 patients with PSP and 39% in 73 patients with secondary spontaneous pneumothorax. In this cohort, on the other hand, PAL was defined as an air leak exceeding 5 days, and the PAL rate was 20.7% in 140 PSP patients. Our results revealed that SUM7to8 is the most powerful predictor of PAL and that PAL can be predicted with a PPV of 69% and NPV of 100% when SUM7to8 ≥ 1. In only one of our 29 patients with PAL, the score obtained on the fourth day was zero, and air leak started again in this patient the next day. In the other 28 patients, the score on the fourth day was ≥ 1. In simple terms, the detection of air leakage on the fourth day after chest tube insertion in PSP is an invaluable criterion for PAL. In this case, a longer waiting period may not be required for surgical intervention due to air leak in patients who are suitable for surgery.

In our study, we compared patients with and without PAL in terms of some basic characteristics as well. We found accordingly that age, gender, pneumothorax side, leukocytosis, smoking, and recurrent pneumothorax did not represent a significant difference between the two groups. Akamine T et al [2] reported in their study that there was no difference between the two groups in terms of age, gender, smoking, and pneumothorax side. Comparing these two groups, they reported that PAL was significantly higher only in those admitted to the hospital within the first 24 hours after symptom onset.

This study has the following potential limitations. The major limitation is the semi-quantitative evaluation of air leakage by more than one person. Our air leak grading is based on a subjective assessment despite being performed by our residents. There may be those who question its reliability on that account. However, we can assume that there is a high consistency among observers because of the simplicity of the evaluation method. Other limitations include the single-center nature of the study and sample size. We tried to overcome both limitations by including enough patients and using proper statistical methods.

In conclusion, the presence of air leakage on the fourth day following chest tube in PSP is a significant marker for PAL. Despite being a semi-quantitative method, visual assessment of air leaks is a simple and robust independent variable predicting the development of PAL. Data from larger and multicenter patient series may provide a consensus on the prediction of PAL. In this way, we believe that we can decide on earlier surgical intervention and prevent problems such as pneumonia, empyema, and prolonged hospital stay.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

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Ethics approval

This study was approved by the designated Ethics Committee of University of Health Sciences, Dr. Suat Seren Chest Diseases and Chest Surgery Training and Research Hospital. The approval number is 49109414-604.02-7018.

Authors' contributions

SY, BY: made substantial contributions to the design of the work, BAŞ, AÜ, EÇÇ: made the analysis of data, AÜ, SY:
made the creation of new software used in the work, BAŞ, SY: have drafted the work, AÜ, SG: revised it.

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Review Article

VATS sleeve resections

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ABSTRACT

For many years, pneumonectomy was considered the only type of surgery, especially for centrally located or locally advanced lung tumors. Bronchoplastic resections such as bronchial sleeve lobectomy have been developed as an alternative to pneumonectomy, which is a radical resection with parenchyma-sparing properties. As a result of the increasing use of video-assisted thoracoscopic surgery and the adaptation of extended resections to it, the use of VATS in sleeve resections has become widespread.

Keywords: video-assisted thoracoscopic surgery, sleeve resection, bronchial sleeve resection

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Introduction

Sleeve resections are a specialized surgical method to preserve lung tissue in the treatment of benign or malignant lung pathologies. Bronchial sleeve lobectomy was first introduced as parenchyma-sparing surgery by Sir Clement Price-Thomas in 1947, and in 1954 Allison performed the first sleeve lobectomy for bronchogenic carcinoma. The first case of VATS bronchial sleeve was reported by Santambrogio et al in 2002, while the first case of uniportal VATS sleeve lobectomy was added to the literature by Diego Gonzalez-Rivas et al in 2013 [1-3].

Sleeve lobectomy is generally performed in approximately 5% of all lung resections. The basis of sleeve resection is bronchial sleeve resections. Bronchial sleeve resections are a form of bronchoplastic resection based on the removal of diseased bronchial tissue together with tumor-containing lung parenchyma and anastomosis of intact bronchial orifices. Bronchial sleeve resections are performed as alternative operations to pneumonectomy in benign diseases as well as malignancies in order to preserve intact lung parenchyma. Segmenter resection, reconstruction, or angioplasty interventions can be performed on the pulmonary artery with or without bronchial sleeve resection. It is usually applied in three ways: 1st sleeve lobectomy (bronchial sleeve), 2nd vascular sleeve resection and 3rd sleeve pneumonectomy [1,4].

Sleeve lobectomies are mostly performed for tumors located at the mouth of the lobe bronchus and progressing to the main bronchus. Although bronchoplastic techniques are applicable to both main bronchi and all five major lobe bronchi, sleeve lobectomy is mostly performed in right or left upper lobe endobronchial tumors. Sleeve right upper lobectomy is the most commonly performed sleeve resection with a rate of approximately 70%. Sleeve lobectomy is less commonly performed when a lymph node invades the bronchial wall. The indication for sleeve resection with this type of lymph node involvement was seen in 21% of patients in the study conducted by Deslauriers et al in 1993 [5,6].

During surgery, after providing a suitable field of view and revealing the vascular and bronchial structures, solid margins on the bronchus should be determined and an incision should be made with a scalpel perpendicular to the long axis. The frozen section should be performed from the distal and proximal bronchial surgical margins and surgical margins should be expanded in case of tumor. Similarly, when excessive tension or impropriety in the anastomosis cannot be eliminated by various maneuvers, resection should be completed with pneumonectomy if necessary, considering the consequences of anastomotic leakage. In the anastomosis, care should be taken to ensure that the cartilage and membranous faces are opposite. The anastomosis can be completed with continuous suturing technique, separated suturing technique, or both techniques together [7-9].

Sleeve right upper lobectomy

Sleeve right upper lobectomy is the most commonly performed sleeve lobectomy. In the surgical technique, bronchial structures are exposed just below the azygos vein for sleeve lobectomy after dividing the arterial and venous branches of the right upper lobe and completing the fissure. If necessary, the azygos vein can be divided to provide better working space. Extensive radical dissection in the peribronchial area may lead to disruption of the vascular supply and ischemia of the anastomosis, so it is recommended to keep the peribronchial dissection minimal in these areas.

For sleeve right upper lobectomy after dissection, the right main bronchus is divided with a scalpel proximal to the upper lobe bronchial outlet. Similarly, the right intermediate bronchus is divided with a scalpel proximal to the middle lobe bronchial outlet. During bronchial division, the incision should be made in a smooth way perpendicular to the lumen. After the bronchial divisions are completed, the right upper lobe piece is taken out and subjected to frozen examination in both bronchial surgical margins. If the tumor is detected in the margin examination, the margins should be moved further by making a new incision from the bronchial stump or further resections such as pneumonectomy should be performed. In anastomosis, care should be taken to ensure that the membranous and cartilage faces face each other at both ends. Another important point is not to allow tension to build up at the anastomosis, which can be achieved by releasing the pulmonary ligament, pericardial, or hilar release maneuvers to increase lung mobilization. When there is a diameter mismatch between the right main bronchus and the intermediate bronchus, a telescopic anastomosis in which the distal end passes into the proximal end can also be performed. Single suture application, continuous suture technique, or both of these techniques can be used to complete the anastomosis. Absorbable or non-absorbable sutures can be preferred as material (Figure 1). After the anastomosis is completed, ventilation is provided with a pressure of 25-30 cm H2O, air leakage control is applied from the anastomosis. Supporting the anastomosis with structures such as intercostal muscle flap, pleura or thymic fatty tissue can be applied [10,11].

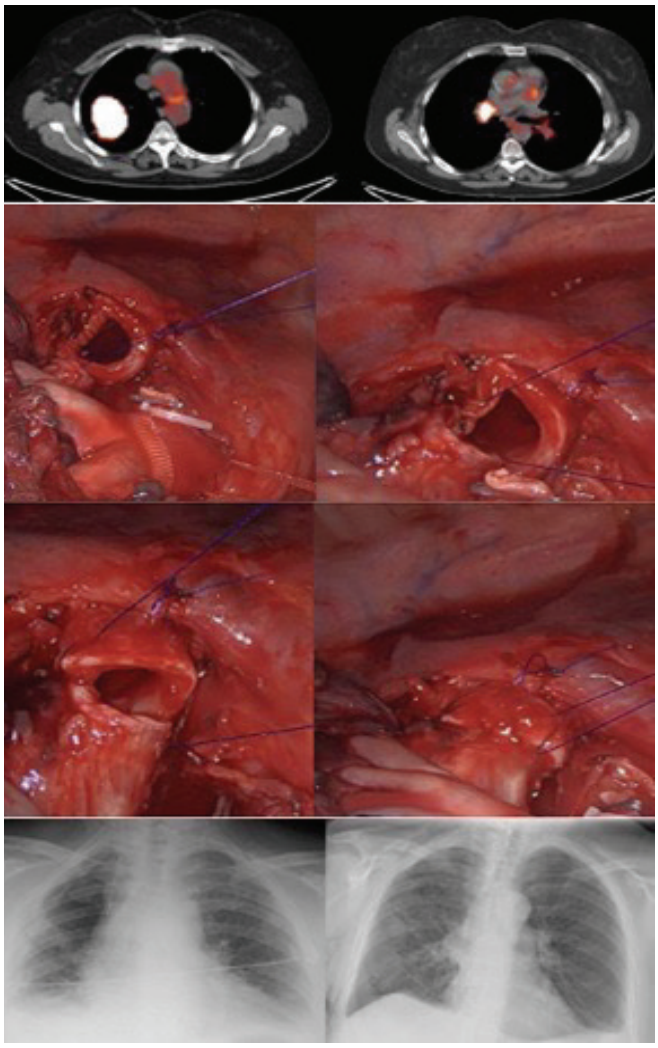

Figure 1. The patient was examined after a complaint of cough and was diagnosed with adenocarcinoma on transthoracic needle aspiration diagnosis upon detection of a right upper lobe mass. After preoperative evaluation, VATS right sleeve upper lobectomy was performed due to perioperative hilar lymph node invasion. Postoperative first-day and postoperative fifth-day chest radiographs are shown in the images above. There were no postoperative complications and the patient was discharged on the fifth postoperative day.

Sleeve left upper lobectomy

Left-sided resections are more difficult because of the narrow vision. The aortic arch and left pulmonary artery limit access to the left main bronchus. There is also a risk of injury to the left recurrent nerve that travels under the arcus aorta.

In sleeve left upper lobectomy, the bronchial area is exposed by tilting the lung anteriorly after dividing the vascular structures extending to the upper lobe. At this stage, rotation, and lateral exclusion of the interlobar pulmonary artery will widen the visual angle. For sleeve left upper lobectomy, bronchial incisions are made in the left main bronchus and proximal to the left lower lobe superior segment outlet. The left lower lobe bronchus is anastomosed to the left main bronchus after verification of clean surgical margins by excising the upper lobe bronchus. Due to the length of the left main bronchus, the proximal bronchial incision can be made higher up. However, the anastomosis becomes technically difficult as you go proximally, especially because the arcus aorta restricts vision. Mobilization and careful retraction of the arcus aorta can be performed to provide additional visualization. Hilar release can be performed by dividing the pulmonary ligament and making a 'U' shaped pericardial incision at the level of the inferior pulmonary vein to reduce the tension in the anastomosis.

A centrally located tumor requiring sleeve lobectomy may also invade the pulmonary artery and arterial reconstruction may be required. This type of bronchial and vascular reconstruction is most commonly seen in sleeve left upper lobectomy among sleeve lobectomies [10-12].

Other sleeve resections have the same technical characteristics as thoracotomy in accordance with oncological principles.

Tips for VATS sleeve surgery

Different methods such as uniportal, two or three ports can be used in VATS sleeve resections. It is important to choose the optimal method for the primary surgeon's preferred field of view and instrument use. In our clinic, we use a biportal approach with a 4 cm utility incision in the fourth or fifth intercostal space in the mid-axillary region and a camera port in the seventh intercostal space. Although we use a biportal approach during the division of vascular structures, we switch to a uniportal approach when bronchial anastomosis is started in upper sleeve lobectomies. The assistant stands posterior to the patient while holding the camera posterior to the uniportal incision. The interlobar pulmonary artery is turned total and suspended with silk or nylon tape and pulled away from the anastomosis line with a clamp from the camera port to facilitate visualization of the anastomosis area. Anastomosis is started from the farthest corner of the posterior area with a 3/0 polypropylene suture. Passing the first suture inside to out proximal to the anastomosis line allows the surgeon to work forehand. The side of the first suture thread to be suspended is passed through the chest wall and suspended (Figure 2). This prevents tangling of the anastomotic suture threads. Among the recommendations, the fact that the camera assistant is a person who can perform VATS lobectomy contributes significantly to shortening the operation time.

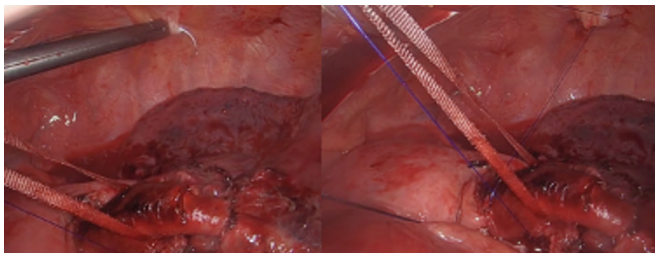

Figure 2. In a patient who underwent left sleeve upper lobectomy for a left upper lobe bronchial orifice mass, the interlobar pulmonary artery is suspended with nylon tape and the left main bronchus is suspended with a fixation suture. The posterior suture of the anastomosis suture is fixed by passing through the chest wall to prevent tangling of the sutures.

Anesthesia in VATS sleeve surgery

In our clinical practice, we use a double-lumen endobronchial tube, bronchial blocker, or jet ventilation under general anesthesia in patients scheduled for sleeve bronchial surgery (Figures 3,4). Although a double-lumen endobronchial tube is our most preferred method for single lung ventilation, we also frequently use bronchial blocker with fiberoptic bronchoscopy when the patient's airway is difficult. Jet ventilation is performed with a tritube and an accompanying bronchial blocker in cases of carinal sleeve. As a result of working in harmony with the surgical team in case of implementation difficulties, we provide a sterile breathing circuit in the surgical field and ventilation continuation with an endotracheal tube advanced distal to the anastomosis.

Thanks to our experience in the use of fiberoptic bronchoscopy, we often have no difficulty in single lung ventilation, but we assist the surgical team in endobronchial imaging when used intraoperatively (Figure 3). In sleeve surgeries, providing comfort to the surgical field shortens the operation time and reduces the complications that may occur in the patient.

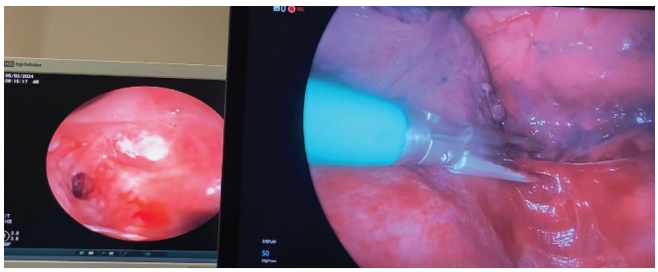

Figure 3. Contribution to the surgical field with the use of perioperative fiberoptic bronchoscopy in VATS sleeve cases.

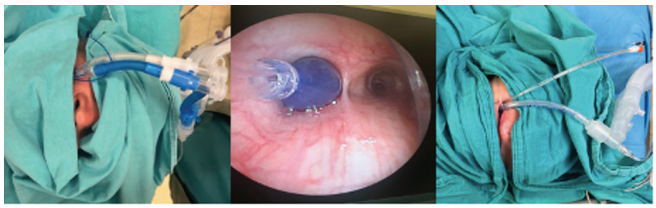

Figure 4. Intubation methods, respectively: Double lumen tube, endobronchial blocker and jet ventilation.

The most mortal complication that may occur in sleeve resections is early anastomotic line separation. Bronchovascular fistula, bronchial stenosis and atelectasis are other major complications. In Tedder's publication in which 1125 cases of sleeve lobectomy performed in different centers were examined, the rate of pneumonia was 6.7% and the rate of atelectasis was 5.4%. The development of pneumonia and atelectasis has been associated with loss of ciliary function and mucosal damage at the anastomotic line. To minimize these complications, bronchoscopy in the operating room immediately after surgery is recommended. Indications for bronchoscopy in the postoperative period include persistent wheezing, the appearance of atelectasis or lobar consolidation on chest radiography, or prolonged air leakage exceeding seven days [8,13].

Anastomotic complications, especially bronchial stenosis, bronchovascular and bronchopleural fistula, can be reduced by using of living tissues between bronchial and vascular structures and supporting the anastomosis with anatomical structures. Among these complications, bronchopleural fistula has been reported between 1-14% after sleeve resections [10]. Since hemoptysis in the postoperative period after sleeve lobectomy may be a sign of a bronchovascular fistula, urgent bronchoscopic evaluation is required [13].

In the study by Gao et al in 2019, after 54 VATS sleeve and 94 thoracotomy sleeve cases were evaluated with propensity score, 39 cases were included in each group. The results of the evaluation showed that VATS resulted in significantly less blood loss, chest tube and hospital stay. The mean operation time was 300 minutes with VATS and 221 minutes with thoracotomy. A decrease in economic costs was found in VATS resections. No difference in postoperative complications was observed between both groups [14].

Deng et al performed a meta-analysis of 5 studies in which VATS sleeve and thoracotomy sleeve were performed after evaluation of the literature. A total of 436 cases were evaluated; the VATS sleeve group had less blood loss, longer operation time, and shorter hospital stays. Postoperative complications were 13.5% in the VATS group and 15.7% in the thoracotomy group with no significant difference. Three-year survival was 72.5% in the VATS group and 66.8% in the thoracotomy group and no significant difference was observed [15].

Huang et al analyzed 118 VATS bronchial sleeve cases. Three port approaches were used. Mean operation time was 124 (118-223) minutes and bronchial anastomosis time was 30 (15-42) minutes. The mean postoperative drainage period was 5 (3-8) days. In a single case, bronchial leakage was detected on the 12th postoperative day and the patient died with massive hemoptysis [16].

Soultanis et al analysed 79 cases of uniportal sleeve lobectomy. Mean operation time was 180 (maximum 390) minutes and blood loss was 100 (maximum 1480) ml. The postoperative drainage period was determined as 3.8 days. In the series, thoracotomy was performed in one case due to massive hemorrhage and revision was performed in one postoperative case due to hemorrhage. Atelectasis, pneumonia, and anastomosis-related complications were not detected. One month later, all patients were evaluated by bronchoscopy and anastomosis lines were found to be normal [17].

In the study by Huang et al, 13 cases of thoracoscopic double sleeve were analyzed. Mean operation time was 264 (218-330) minutes and pulmonary artery clamping time was 72 (44-143) minutes. The mean pulmonary artery anastomosis time was 45 (26-75) and the mean bronchial anastomosis time was 31 (15-50) minutes. In the series, 30-day mortality was not detected and postoperative pneumonia was observed in one patient [18].

In our clinic, the number of VATS sleeve resection cases has increased in the last two years. With our experience, we found no difference in operative time between thoracotomy and VATS cases. We observed a shorter duration of tube drainage and hospitalization in VATS cases.

In conclusion, with the increasing experience in minimally invasive approaches, thoracoscopic surgery has started to be used at higher rates. VATS sleeve resections have started to be performed with the developing endoscopic instruments and surgical techniques. VATS without compromising oncological principles resulted in less surgical trauma and faster postoperative recovery. Considering these reasons, we recommend VATS sleeve lobectomy in clinics with high thoracoscopic experience.

Declaration of conflicting interests

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Authors' contribution

MÜ,EG,MM: conceived and designed the review, cowrote the paper, collected the clinical data. The authors discussed the paper under the literature data together and constituted the final manuscript.

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Review Article

Pediatric esophageal emergency: practical algorithms for the diagnosis and treatment from thoracic surgery perspective

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ABSTRACT

Pediatric esophageal emergency pathologies such as esophageal perforation, corrosive esophagitis and esophageal foreign bodies are complex clinical conditions. Most important point of these pathologies are taking a careful history, focused physical examination, and screening laboratory tests. The mortality and morbidity rates are depending on the time between diagnosis and treatment. The aim of the study is to develop practical algorithms in diagnosis and treatment from the perspective of thoracic surgery that guides preclinical and specialized clinical physicians in the treatment of pediatric esophageal emergency pathologies.

Keywords: esophagus, perforation, emergency, foreign body, corrosive

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Introduction

Pediatric esophageal emergency pathologies, consisting of esophageal perforation, corrosive esophagitis, and esophageal foreign bodies, are conditions that have extremely dangerous consequences in terms of both morbidity and mortality. Treatment options should be determined and applied specifically to the patient, diagnosis, severity of the condition, and other medical conditions [1]. The Most important point of these pathologies are taking a careful history, focused physical examination, and screening laboratory tests. And also, the most important point determining the mortality and morbidity rate is the time between diagnosis and treatment [1,2].

The review aims to develop an algorithm that guides preclinical and specialized clinical physicians in the treatment of pediatric esophageal emergency pathologies. We believe that this will enable the effective and prompt identification and treatment of rare conditions associated with pediatric esophageal issues.

Corrosive esophagitis

Corrosive injuries result from the ingestion of caustic or corrosive substances through the oral route and can lead to erosive esophagitis with strictures in the chronic phase. Although acknowledging a continuous decrease in developed nations, the annual incidence is estimated to be between 5,000 and 15,000 cases globally. The clinical manifestations of caustic ingestion in children can range from no injury to fatal outcomes. It's important to note that nearly all corrosive injuries in children are accidental [1].

Caustic injuries are more commonly observed in countries where preventive measures are lacking, often due to social, economic, and educational factors. Approximately half to 80% of these injuries occur in children. While preventive measures have successfully reduced caustic injuries in many countries, there is still a need for the realization of this goal in numerous developing nations. The ingestion of highly alkaline or acidic substances remains a significant cause of morbidity and mortality globally, particularly in developing regions [1,2].

Accidental caustic ingestion poses the highest risk for children under 5 years old due to their curiosity and well-developed skills to find and drink potentially toxic substances. Risk factors for corrosive injuries in this group include male gender, attention deficit hyperactivity disorder, lower parental education, young maternal age, low socioeconomic status, and living in rural areas (Figure 1).

Approximately 20-40% of individuals who ingest caustic substances develop erosive esophagitis. The severity of corrosive esophagitis depends on factors such as the amount, concentration, pH, and duration of contact with the caustic agents [2]. Risk factors of caustic ingestion in children are shown in table 1.

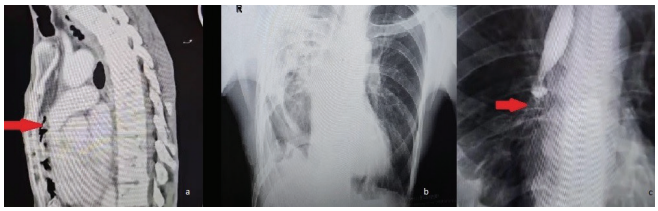

Figure 1. Air images belonging to the colon in the retrosternal area on thoracic CT of the patient who underwent esophagocolostomy **(A)**, volume loss and pleural thickening in the right hemithorax on Chest X-ray **(B)**, leakage of contrast material from the intrathoracic esophagopleural fistula on esophagography **(C)**.

Table 1. Risk factors of caustic ingestion in children [3-11].

Risk factors
• Male gender
• Attention-deficit/ hyperactivitydisordersymptoms
• Lowerparentaleducationstatus
• Young maternal age
• Lack ofparentalsupervision
• Rural abode.

Both alkali (pH; 4-11.5) and acid (pH; less than 2) substances can cause significant burns to the cheeks, mouth, oropharynx, esophagus, and stomach, and rarely to the duodenum, as well as the airway. Serious long-term gastrointestinal morbidity occurs in 7-25% of cases, whether or not a stricture is present. Esophageal injury, with or without stricture, results in fibrosis, and abnormal esophageal peristalsis may lead to dysphagia dysphagia [12-14].

In children ingesting caustic substances, the development of strictures ranges from 10% to 75%, depending on the concentration involved. Alkaline ingestion is more prevalent in Africa, the Americas, and Oceania, while acid ingestion is more common in Europe and Asia for children. Despite the higher prevalence of acid ingestion in certain regions, stricture formation is more commonly associated with alkaline ingestion. The incidence of stricture formation after acid ingestion in children is reported to be in the range of 2.9% to 15.3% [15].

The mechanism of tissue damage caused by caustic substances depends on their pH. Acidic substances cause coagulation necrosis due to protein denaturation,

while alkaline substances cause liquefaction necrosis by destroying cell architecture. As a result, acids typically cause superficial injuries, whereas alkalis cause deeper injuries. While it's not an absolute rule, acidic substances often lead to long-segment gastrointestinal injuries, while alkaline substances tend to cause more limited injuries in the esophagus [16,17].

In the first week after caustic ingestion, mucosal damage and bacterial invasion become apparent. Full-thickness injuries during this period can lead to perforation. Esophageal remodeling begins around the start of the second week, and as a result, endoscopy is typically not performed between 5 and 15 days after the injury. Scar retraction starts by the third week, driven by fibroblast proliferation. Mucosal re-epithelialization begins during this period and is usually completed by the sixth week after the injury. This timeline highlights the dynamic process of tissue response and repair following caustic ingestion [2].

Presentation and emergency department treatment

Patients typically present to the emergency department following the ingestion of a caustic substance. If the ingested substance is solid, it often causes oropharyngeal injuries, while liquids can result in burns to the esophagus. The presence of oral injury generally indicates esophageal injury as well. However, the absence of oral injury does not rule out esophageal injury. In patients with caustic injury but no oral lesions, approximately 1% may develop esophageal strictures in the chronic period [13].

Many patients are initially asymptomatic, but despite this, esophageal injury can be detected in a significant number through endoscopy. In 6-18% of patients, oropharyngeal and laryngeal injuries may lead to symptoms such as hoarseness, stridor, dyspnea, tachypnea, or wheezing. Severe injuries can result in transmural necrosis, perforation, and mediastinitis, although this is very rare. If a patient develops fever, tachycardia, severe retrosternal or abdominal pain, hemorrhage, sepsis, or organ dysfunction develop in a patient, urgent surgical intervention may be necessary.

The presence of symptoms like drooling, dysphagia, and epigastric pain may indicate a possible gastrointestinal injury. Severe injuries are suggested by vomiting and hematemesis. If a patient shows signs of gastrointestinal injury, such as drooling, dysphagia, and epigastric pain, or if severe symptoms like vomiting and hematemesis are present, it indicates a more severe gastrointestinal injury, and prompt medical attention is crucial.

Treatment

Firstly, it is necessary to determine the type and quantity of the ingested substance. The patient should never be induced to vomit. Neutral liquid such as water or milk can't be given due to concerns regarding potential further harm from heat injury during the neutralization process, diluting agents should be avoided, as they pose safety risks. During this process, it is crucial to start intravenous fluid infusion for the patient [18].

If there is an airway injury, respiratory stabilization (intubation and/or tracheostomy) should be prioritized, followed by an evaluation of the esophagus. Approximately 18% of patients may require emergency tracheostomy, and 1% may need chronic tracheostomy [19].

Although there is no evidence in the literature, broad-spectrum antibiotic therapy can be initiated or prophylaxis can be applied before endoscopy due to the potential for perforation and other bacterial complications [20].

The first diagnostic test should be a posteroanterior chest X-ray. The X-ray is used to evaluate mediastinal widening, mediastinal emphysema, intra-abdominal free air, and pneumothorax. The gold standard for detecting esophageal injury is esophagogastroduodenoscopy. Endoscopic evaluation should be performed within the first 24-48 hours and under general anesthesia, as the risk of perforation is lowest during this period. Additionally, to minimize the risk of possible perforation, air insufflation during endoscopy should be minimal or avoided altogether. The endoscope should not be blindly advanced, and the procedure should be terminated if injury is observed. In cases of potential severe injury, careful nasogastric tube placement with endoscopic visualization should be performed to facilitate enteral nutrition and prevent gastric content treatment at the site of injury injury [21-23].

The Zargar et al classification system proposed in 1994 is commonly used to grade esophageal injuries in clinical practice [20,24] (Table 2). In the acute phase, the presence of perforation, its location, and dimensions, along with accompanying complications such as mediastinitis, pneumonia, etc., can be assessed using contrast swallow studies with water-soluble contrast (X-ray and/or CT). In the chronic phase (3-6 mounts later), potential stricture development, pyloric obstruction, or the evaluation of treatment response after dilation following stricture development can also be assessed using these imaging techniques [25,26].

Table 2. Classification in caustic injuries.

Grade	Endoscopic appearance	Risk of perforation (%)	Incidence %	Treatment
0	No evidence of injury	0	11–57	Observed in hospital until full oral feeds are tolerated
I	Mucosal erythema and oedema	0	11–88	
II				2-4 weeks hospitalization A liquid diet, either orally or via nasogastric tubes
A	Superficial non-circumferential erosion, ulcers, haemorrhage or exudate	<5	7–26	
B	Deep or circumferential ulceration	71	13.6–28	
III				
A	Multiple scattered ulcerations with patchy necrosis	100	0.5–12	
B	Extensive necrosis		0–1	

Preventive treatment

PPIs or histamine H2-receptor antagonists: To reduce stomach acid.

Oral nystatin suspension: To prevent endogenous fungal overgrowth, exacerbation of stricture formation, and colonization of the nasogastric tube. It should be used for 3 weeks.

Nasogastric tube placement: For early enteral feeding.

Steroids: The use of high-dose methylprednisolone (1 g/1.73m2 daily for 3 days) decreases stricture formation. However, the use of steroids in caustic esophagitis is controversial. It has been determined that patients with first or third-degree esophageal injuries do not benefit from steroid use. Still, steroids can prevent stricture formation in patients with second-degree caustic esophagitis [1,28-30].

Treatment of long-term complications

Esophageal strictures

Esophageal strictures in children are most commonly caused by caustic injuries. Strictures are most commonly determined in the cervical and middle thoracic esophagus, with an incidence ranging between 2% and 49%. It has been demonstrated in the study conducted by Nunes et al that severe endoscopic lesions, involvement of the entire length of the esophagus, hematemesis, and increased serum lactic dehydrogenase represent risk factors for the development of fibrotic strictures induced by caustic ingestion. Serial stricture dilation is the mainstay of therapy for esophageal strictures. However, esophageal replacement is the most suitable treatment choice for long and/or refractory strictures [1,27-29].

If patients experience symptoms of dysphagia, and a stricture is identified endoscopically, a dilation program can be initiated 3 weeks after the injury. The success rate of dilation is very high for non-lye strictures, strictures under 5 cm in length, strictures in the upper third of the esophagus, and in younger patients (under 8 years of age). Weekly to bi-weekly dilations over 3 months, with an average of 12 dilations, are required for strictures due to corrosive injuries. The perforation rate of dilation ranges from 0.4% to 17.4% [1,5,8].

Esophageal replacement surgery is required in 18% of patients who experience perforation during dilation, and the mortality rate increases to 18% in such cases [9]. Some reports suggest that the frequency and necessity of dilatation may decrease with the injection of steroids and/or mitomycin into the stricture area, although there are limited pediatric reports on this approach [9].

Stenting of esophageal strictures with double-tube polyamide and silicone, self-expanding covered metal (nitinol) stents, or polydioxanone absorbable stents may be considered as a good alternative to serial/multiple dilations or surgery. However, there are challenges associated with stenting in pediatric cases, including the lack of stents suitable for children, high costs, stent migration, and the potential for secondary stenosis due to granulation tissue in the proximal and distal parts of the stent [1,30]. The diagnosis and treatment algorithm for caustic injuries is prepared based on the literature data and our clinical experience (Figure 2).

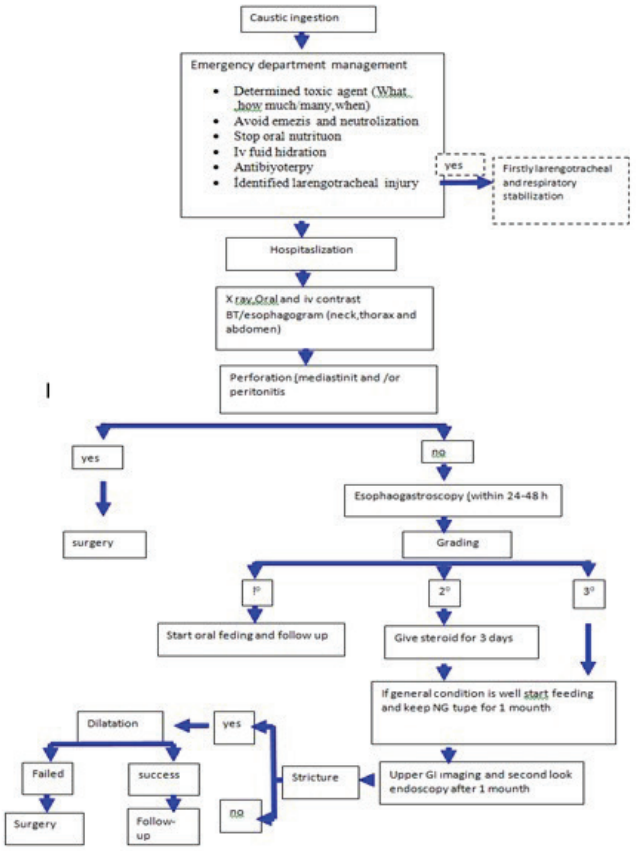

Figure 2. Algortim in diagnosis and treatment of caustic esophagitis.

Esophageal perforation

Esophageal perforation (EP) is rare in the neonatal population, with an incidence reported as 0.006% in large series [31]. The first spontaneous esophageal perforation due to the esophageal web was reported by James Fryfogel in 1952. Additionally, the first iatrogenic esophageal perforation was reported during stiff rubber catheter suctioning in a 28-day-old infant in 1961 [32].

The esophagus is highly susceptible to trauma and injury due to the absence of supporting tissue around its serosal layer. Once an injury occurs, bacterial spread and the inflammatory response can rapidly and easily lead to complications. Polymicrobial flora dominated by anaerobes, along with gastrointestinal content, can spread into the mediastinum, resulting in conditions such as mediastinitis, empyema, abscesses, sepsis, and multiple organ dysfunction syndrome, all of which have high mortality and morbidity rates [33].

Despite improvements in post-operative intensive care unit management, antibiotic therapy, and advances in enteral and parenteral nutrition, esophageal perforation remains a life-threatening condition. The mortality rate has recently been reported as 28%. It's crucial to note that after the diagnosis of perforation, mortality doubles for every 24 hours that pass without treatment [34].

Etiology

Esophageal perforation can occur due to various reasons, with endoscopic stricture dilation and nasogastric tube insertion. The table given below outlines the most common causes of esophageal perforation (Table 3). In children, the most frequent causes include iatrogenic traumas, lye burns or chemical burns, direct and indirect trauma, ingestion of foreign objects (Figure 3), operative trauma, and idiopathic causes.

Table 3. Reasons of esophageal perforation.

Reasons of esophageal perforation	
Intraluminal	**Extraluminal**
1-Endoscopicaly	1-Penetran
>Esophagoscopy	>Gunshot wound
>Dilatation	>Stab wound
>Intraesophageal tube insertion	>Foreign bodies erosion
>Biopsy	
>Skleroterapy	2-Blunt injury
>Endotracheal tube	>Traumas
	>Resustation
2-Nonendoscopic injuries	
>Barotrauma	3-Operative trauma
>Coustic injuries	
3-Foreign bodies	

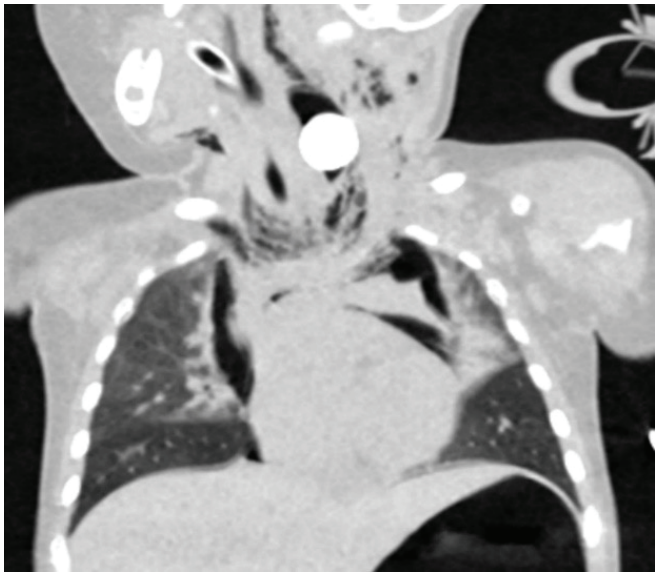

Figure 3. A 3-year-old male patient who swallowed a coin. On thoracic CT, there is a coin in the cervical esophagus, esophageal perforation, and mediastinal emphysema (From the archive of the Department of Thoracic Surgery, Erzurum Atatürk University Faculty of Medicine with permission).

Clinical presentation

Symptoms of esophageal perforation can vary based on the cause, location of the perforation, and the time between diagnosis and treatment. However, the most common symptoms include dysphagia (60%), dyspnea, and fever. In cervical perforations, symptoms tend to be less severe as the spread of contamination from the retroesophageal space to the mediastinum is slow. On the other hand, thoracic perforations lead to rapid contamination of the mediastinum, resulting in symptoms of systemic sepsis and shock within 24 hours. Gastric contents and bacterial flora from the gastrointestinal tract infiltrate the mediastinum, causing severe necrotizing mediastinitis. Negative intrathoracic pressure can worsen pleural rupture, leading to pleural effusion and pneumothorax. In intra-abdominal esophageal perforations, peritonitis is a common presentation, and symptoms may appear within a few hours [35,36].

In neonates, symptoms of esophageal perforation may include hypersalivation with choking, coughing, or cyanosis during feeding. Neonates might also present with a pneumothorax. Fever is often observed in the first 24 hours after challenging endotracheal intubation or nasogastric tube insertion [34]. Symptoms according to the location of the perforation are shown in table 4.

Table 4. Symptoms according to the location of the perforation.

Localization of perforation	Symptoms
Cervical	Neck pain Cervical dysphagia Dysphonia Bloody regurgitation Subcutaneous emphysema Leukocytosis Swelling Redness in neck
Thoracic	Chest pain Tachycardia Tachypnea Fever Leukocytosis Subcutaneous emphysema
Abdominal	Abdominal pain Shoulder pain Dysphagia Drooling Local tenderness

Diagnosis

The diagnosis of esophageal perforation can be made through various methods. Although it is normal in 12-33% of patients, neck and chest X-rays should be the first diagnostic test in patients with suspected esophageal perforation. A plain X-ray can demonstrate the localization of the enterogastric tube, pneumothorax, pleural effusion, pneumomediastinum, and mediastinal enlargement. In a patient with findings suggestive of esophageal perforation on X-ray, the diagnosis is confirmed through a contrast-enhanced esophagogram and endoscopy. These examinations help to determine the location and size of the perforation, with a reported sensitivity of 100% in the literature [37].

In clinical practice, especially in infants, endoscopy is not recommended due to the difficulty of application and the risk of increasing the size of the perforation [34,36].

Esophagography findings in esophageal perforation include;

• A collection of contrast in a retropharyngeal pocket from a localized cervical leak.

• A submucosal perforation, appearing as a tract parallel and posterior to the esophageal column.

• Free perforation into the pleural space [32,35,36].

Chest computed tomography (CT) can be very useful in diagnosing esophageal perforation. In patients with esophageal perforation, CT may reveal air and fluid in the extraesophageal area in the mediastinum, esophageal wall thickening, and mediastinal or para mediastinal air-fluid collection, abscess cavities in the pleural space or mediastinum [37-40].

Treatment

Surgical treatment

Surgical indications in esophageal perforation (EP) include clinical deterioration, persistence of a leak despite treatment, massive intrapleural or retropharyngeal spillage, sepsis, mediastinitis, abscess formation in pleural and mediastinal spaces, or even massive or persistent leaks [41].

The most important factor determining post-treatment mortality and morbidity is the time between diagnosis and treatment. The main principles of surgical treatment include the debridement of devitalized tissue from the perforation site, adequate pleural drainage, and elimination of the contamination source. After debriding the devitalized tissue from the perforation site, the

muscular layer and mucosa must be closed with absorbable interrupted sutures. The primary repair site should be reinforced using intercostal, omental, pericardial fat pad, diaphragmatic pedicle graft, rhomboid muscle, latissimus dorsi muscle, and intercostal muscle or pleural flaps. Surgical approaches according to the perforation site are shown in the table 5 [34 -38].

Table 5. Surgical approaches according to the perforation site.

Perforation localization	Surgical apporach
Servical esophageal perforation	Left neck along the lower third of the sternocleidomastoid (SCM) muscle
Mid esophageal perforation	Right thoracotomy at the sixth intercostal space
Distal esophageal perforation	Left thoracotomy in the eighth intercostal space
Abdominal esophagus	Laparatomy

Esophagectomy may be necessary in cases of severe necrosis and multiple injuries due to caustic esophagitis, severe mediastinal contamination, and failure of primary repair. Diversion with cervical esophagostomy might be required if the esophagus is too friable, the patient remains unstable, the repair is not possible due to the size of the defect or friability of surrounding tissue, or widespread mediastinitis prevents primary repair during the initial procedure [34-38].

Recently, minimally invasive surgery has been employed in esophageal perforation. However, there are only a small amount of patient series reported in the literature that were treated with thoracoscopic drainage of the mediastinum, and no mortalities were reported in these series [32,34,36,37].

Non-surgical treatment

In the literature, the total mortality of non-operative treatment in esophageal perforation (EP) is reported to be 18%. This rate is lower than other treatments for EP in childhood compared to adults. Non-operative treatment consists of antibiotics that cover both anaerobes and aerobes, adequate fluid resuscitation, stopping oral intake and starting parenteral nutrition, instituting gastric drainage via gastrostomy or nasogastric tube, and placing a thoracostomy tube. Oral nutritional intake is stopped to decrease further contamination of the wound and allow for esophageal healing [38,39,41,42].If enteral tubes can be safely passed under fluoroscopic guidance, enteral nutrition should be continued. If not, total parenteral nutrition (TPN) should be reserved. Oral feeds can be resumed after an esophagram shows no further leak. It is reported that the average interval to the first esophagram after diagnosis is 7 days, and the average interval to the initiation of oral feeds is 11.5 days [38].

Systemic infection and sepsis progression can be prevented by using broad-spectrum antibiotics that generally cover gram-negative and anaerobic spectra. Typically, antibiotic therapy consists of piperacillin/tazobactam, vancomycin, and gentamicin, along with antifungal agents. The treatment is continued for 7–14 days from the time of perforation diagnosis. If the leak due to perforation persists on esophagography, antibiotic therapy must be continued for an additional 7 days. If pneumothorax and/or pleural effusion are present, drainage must be provided by tube thoracostomy. Pneumothorax has been reported in 32% of patients with esophageal perforation. It is usually seen in the right hemithorax and can be treated with a chest tube or small pigtail catheters [42]. The diagnosis and treatment algorithm for esophageal perforation is prepared based on the literature data and our clinical experience is shown in figure 4.

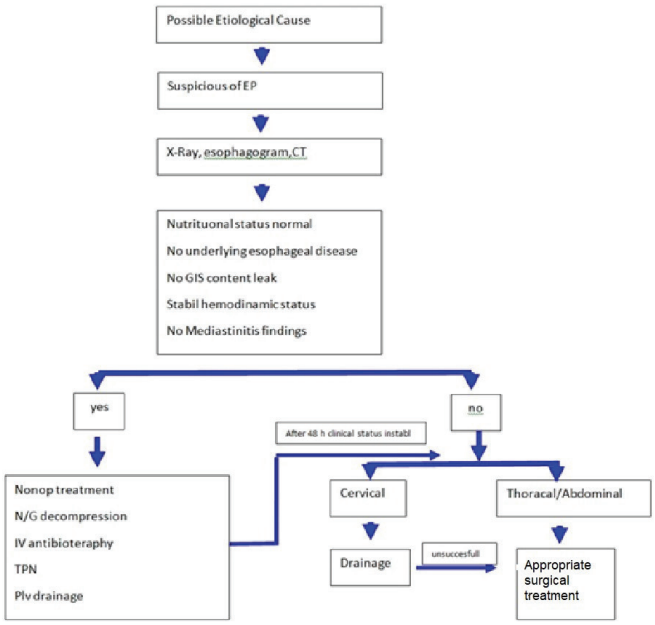

Figure 4. Algoritm in diagnosis and treatment of EP. (Abbrev.; EP:Esophageal perforation, CT:Computed tomography, N/G:Nasogastric tube, IV:Intravenous, TPN:Total parenteral nutrition,Plv: Plevral)

Foreign Bodies

Aerodigestive foreign bodies are one of the most important morbidity and mortality reasons in infants and children. The aspiration of foreign bodies usually cause

a chronic lung infection. and most of the patients admitted to hospital for this reason. Prevalence of foreign body ingestion is reported as 17.9 / 10,000 children who are applied in U.S. emergency departments [43]. The most commonly seen FBs are coins, toys, batteries, and high-powered magnets [44] (Figures 5,6).

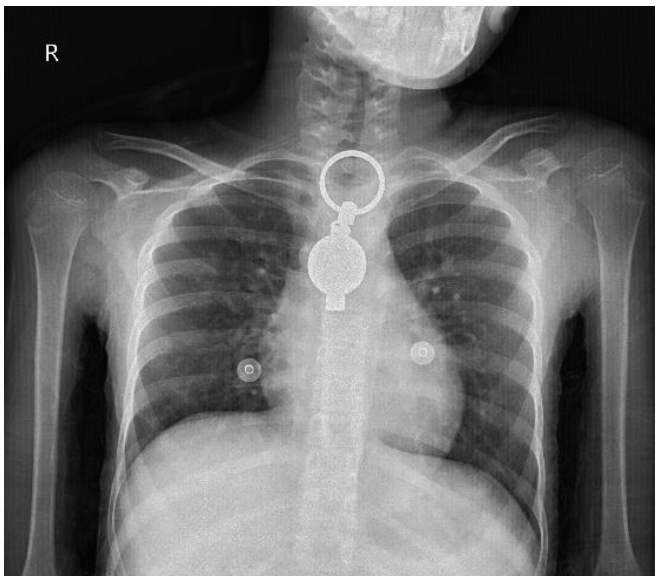

Figure 5. A 12-year-old male patient who swallowed a keychain. On X-ray, a keychain is observed in the upper thoracic esophagus (From the archive of the Department of Thoracic Surgery, Erzurum Atatürk University Faculty of Medicine with permission).

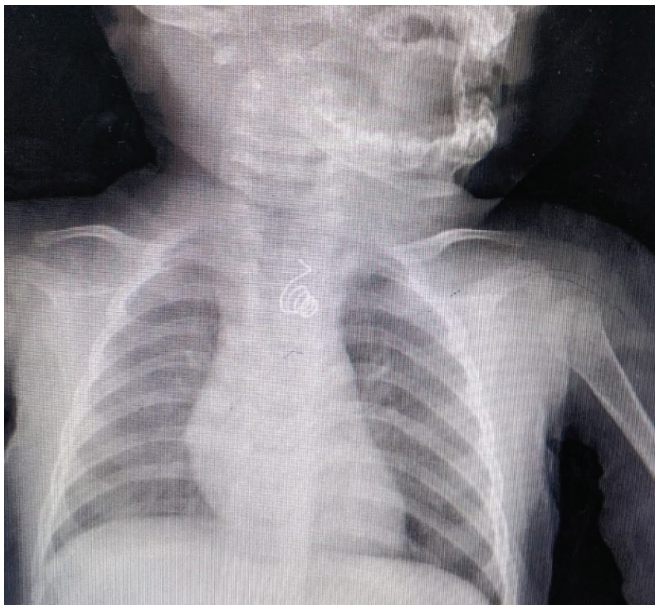

Figure 6. A 5-year-old male patient who swallowed a clothespin spring. On X-ray, a clothespin spring is observed in the upper thoracic esophagus (From the archive of the Department of Thoracic Surgery, Erzurum Atatürk University Faculty of Medicine with permission).

While a lot of GIS foreign bodies pass spontaneously through the gastrointestinal (GI) tract, 40% of esophageal FBs are asymptomatic. For this reason, diagnosis and treatment are delayed and complications that may be mortal and morbid (such as oesophageal perforation, periesophagitis, and mediastinal infection) may appear [45]. The most common symptoms are dysphagia, vomiting, drooling, feeding refusal, and neck and chest pain. According to the European Society of Pediatric Gastroenterology, Hepatology, and Nutrition guidelines, Large FBs even compressing the airway may present with stridor, wheezing, and respiratory distress [46,47].

Because of cricopharyngeal area in the cervical esophagus is the narrowest part of the GIS tract, foreign bodies most commonly lodge in this area. If the FBs cross the cricopharyngeal area, these often pass through into the lower GIS tract and uneventfully are excreted from the intestine [48]. In radiopaque esophageal FBs, diagnostic procedures are firstly neck and chest PA and lateral X-rays even if, plain radiographs of the neck are normal, if a retained esophageal object is suspected by history, examination, or symptoms, an esophagram is needed [49,50].

Treatment

The most common treatment strategies for EFBs in children are rigid oesophagoscopy and Foley catheter balloon extraction. The use of a Foley catheter is used, while the patient is maintained in the Trendelenburg position. Complications of Foley catheter include perforation, aspiration, and acute airway obstruction. The Foley catheter is a safe, efficient, convenient, and practical method for the treatment of children with coins and other blunt EFBs, and it can significantly reduce the need for endoscopy. Some meta-analyses showed that no significant difference between rigid and flexible endoscopy regarding efficacy and safety for the treatment of esophageal foreign bodies [51,52]. However, rigid oesophageal endoscopy under general anesthesia is recommended in Children with EFBs to protect the airway. Moreover, in literature, it is strongly recommended that rigid endoscopy for children because it allows both the use of optical forceps with a strong grasping ability for EFBs and the positioning of sharp and pointed objects inside the rigid endoscope the removal of oesophageal button is extremely more important than other foreign bodies. Because, these cause chemical corrosion, electrical damage, thermal burns, and physical compression

to the oesophageal mucosa. Oesophageal necrosis and even life-threatening complications can occur within 2 hours after accidentally ingesting a button battery. For this reason, in patients, emergency endoscopy and/or operation should be performed without fasting or pre-surgical preparation to reduce the corrosion of the oesophageal mucosa [50-51].

Surgical intervention is indicated in cases of large, sharp-edged foreign bodies embedded in the mucosa that cannot be removed endoscopically and in the presence of perforation. In these situations, employing a surgical method (such as VATS and/or thoracotomy) for the removal of the foreign body would be the safest approach [50-51].

Complications

The complication rate of rigid endoscopy for either airway or esophageal FB is low (0.2%-5%) and mortality is rare (<0.1%). Postoperative complications increase for children who present with a delay in diagnosis greater than 24 hours. Delayed treatment or failed and/or improper treatment can cause complications [51]. The factors of complications in EFB patients are complex. It was shown that sharp foreign bodies and long durations have a higher incidence of complications due to mechanical damage to the mucosa. Risk factors for complications in EFBs are the younger the child, the long implication time of the foreign body, the sharp foreign body, the location of the foreign body, and the presence of fever or cough [49,50].

In young children, the lumen at the entrance of the esophagus is narrow and the oesophageal muscle layer is weak. For this reason, this patient's esophagus is more vulnerable. Sharp foreign body may cause edema and inflammation of the oesophageal mucosa, and long-term compression of the oesophageal mucosa will cause ischaemic necrosis. Esophageal endoscopy performed in a narrow and oedematous oesophageal cavity also increases the risk of mechanical damage and mucosal tearing injury. After 24 h, complication risk significantly increases regardless of the type of foreign body and other factors. All of the esophageal foreign bodies must be removed within 24 h [47-52]. The diagnosis and treatment algorithm for esophageal foreign bodies is prepared based on the literature data and our clinical experience is shown in figure 7.

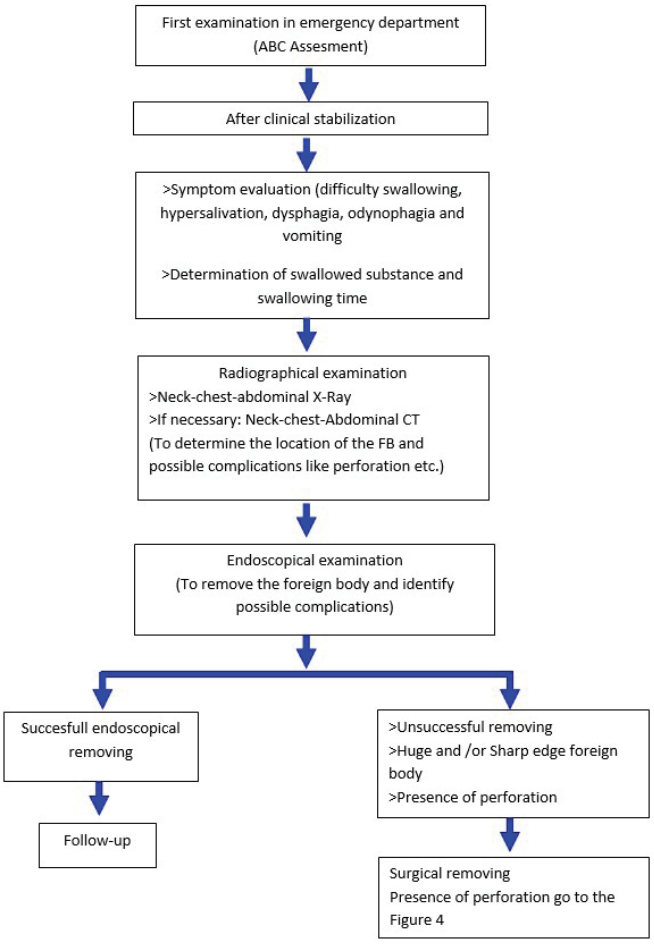
First examination in emergency department (ABC Assesment)
After clinical stabilization
>Symptom evaluation (difficulty swallowing, hypersalivation, dysphagia, odynophagia and vomiting
>Determination of swallowed substance and swallowing time
Radiographical examination
>Neck-chest-abdominal X-Ray
>If necessary: Neck-chest-Abdominal CT
(To determine the location of the FB and possible complications like perforation etc.)
Endoscopical examination
(To remove the foreign body and identify possible complications)
Succesfull endoscopical removing
Follow-up
>Unsuccessful removing
>Huge and /or Sharp edge foreign body
>Presence of perforation
Surgical removing
Presence of perforation go to the Figure 4

Figure 7. Diagnosis and treatment algoritm of esophageal foreign bodies.

In conclusion, pediatric esophageal emergency pathologies are conditions that require long-term multidisciplinary follow-up due to their chronic complications. The most important aspects of managing these pathologies are taking a careful history, conducting a focused physical examination, and performing screening laboratory tests. By doing so, the development of chronic complications, which make treatment most challenging, can be prevented.

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Authors' contribution

MGP,SG,Cİ,ATŞ,YB: conceived and designed the review, co-wrote the paper, collected the clinical data.

The authors discussed the paper under the literature data together and constituted the final manuscript.

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Case Report

Bilateral lower lobe pulmonary hypoplasia in adult

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ABSTRACT

Pulmonary hypoplasia is a bronchopulmonary foregut anomaly characterized by complete or partial aplasia and hypoplasia /or of pulmonary parenchyma, bronchus, and vessels. "Pulmonary hypoplasia" is typically detected in newborns and infants, while it is rare in adults. In this paper, we present a case of pulmonary hypoplasia in a 47-year-old female patient who had hemoptysis and refractory pulmonary infection.

Keywords: pulmonary hypoplasia, bilateral, adult

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Introduction

Pulmonary hypoplasia (PH) is a rare congenital anomaly caused by incomplete development of lung tissue, leading to a decrease in the number of airways and alveoli. This impairment results in respiratory insufficiency and/or various complications [1]. Initially classified by Schneider into three types in 1912 and later modified by Boyden in 1955. PH is rare in adults and patients described in the literature were newborns and infants [2,3]. The types of hypoplasia and their characteristics are outlined in table 1 [4].

This case presents a patient diagnosed with bilateral pulmonary lower lobe hypoplasia during surgery, who subsequently underwent bilateral lower lobectomy.

Table 1. Types of hypoplasia and characteristics in pulmonary hypoplasia [4].

Types	Characteristics
Type 1: Agenesis	Complete absence of pulmonary parenchyma, bronchus, and vessels.
Type 2: Aplasia	Complete absence of pulmonary parenchyma but the presence of a rudimentary bronchus on the affected side.
Type 3: Hypoplasia	There is pulmonary parenchyma but decrease in the number of lung cells, airways, and alveoli.

Case Report

A 47-year-old female patient presented to our clinic with complaints of productive cough, dyspnea, and hemoptysis, along with a history of recurrent pulmonary infections since childhood. The patient reported a history of continuous antibiotic use due to frequent pulmonary infections. Thorax CT revealed atelectasis in bilateral lower lobes, attributed to chronic cystic bronchiectasis (Figure 1). Surgery was scheduled for the patient with a preliminary diagnosis of bilateral bronchiectasis/sequestration.

During exploration (first left, then right lower lobectomy via uniportal VATS, with one month between the two surgeries), both bilateral lower lobes were found to be completely rudimentary (Figure 2). The left lower lobe vein and bronchus were hypoplastic. The left lower lobe common basal segment artery was thin, and the superior segment artery was not visible (Figure 3). The right lower lobe vein was also hypoplastic, and the common basal and superior pulmonary artery branches were not visible. The right lower lobe bronchus was extremely narrow and rudimentary, similar to the left lower lobe bronchus (Figure 4).

Postoperatively, detailed evaluation of pulmonary CT angiography revealed rudimentary continuation of the lower lobe branches of the venous, arterial, and bronchial systems toward the rudimentary lower lobes (Figures 5,6). The patient was discharged at day 3 uneventfully. Written informed consent was obtained from the patient for the publication of her data.

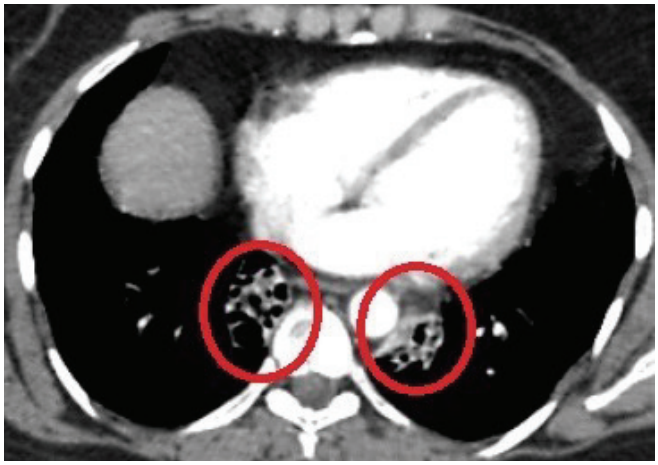

Figure 1. Thorax CT images showing hypoplastic lower lobes bilaterally.

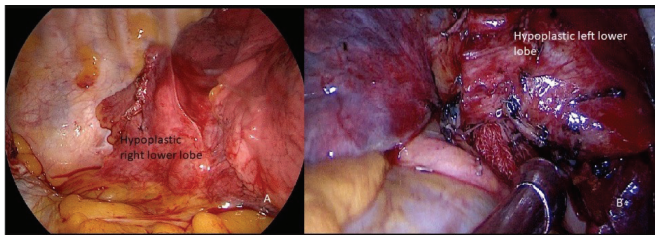

Figure 2. VATS images showing bilateral hypoplastic lower lobes.

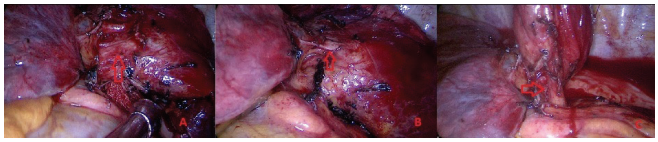

Figure 3. VATS images showing rudimentary left lower lobe arteries **(a),** vein **(b)** and bronchus **(c)**.

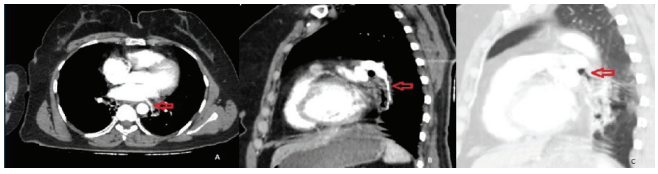

Figure 4. VATS images showing rudimentary and thin right lower lobe arteries **(a)**, vein **(b)** and bronchus **(c).**

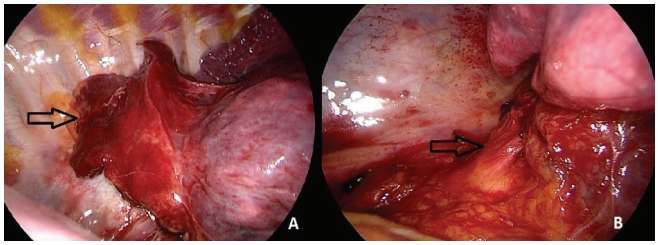

Figure 5. Thorax CT images showing rudimentary and thin left lower lobe bronchus **(a)**, common basal artery **(b),** inferior pulmonary vein **(c)**.

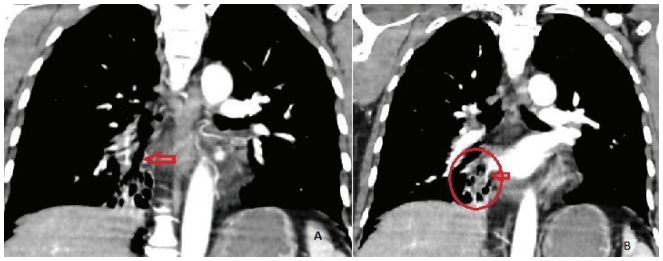

Figure 6. Thorax CT images showing rudimentary right lower lobe **(a)**, thin right lower lobe vein **(b)**.

Discussion

Disruptions in lung development during the intrauterine period can result in clinically significant lung hypoplasia, which may manifest as unilateral, bilateral, or total/lobar hypoplasia. Severe respiratory distress typically occurs immediately after birth, although less severe forms, such as lobar hypoplasia, may remain undiagnosed until adulthood [5]. Hypoplasia is often diagnosed during investigations into the cause of recurrent lung infections or incidentally through chest CT scans taken for other reasons [6].

Congenital anomalies affecting other systems, such as cardiovascular, gastrointestinal, and genitourinary anomalies, may accompany pulmonary hypoplasia, leading to childhood diagnoses. In the absence of accompanying anomalies, patients may remain asymptomatic [7,8]. Diagnosis is usually incidental on chest radiographs, with the left side more commonly affected in adults. Complications like pneumothorax, pulmonary arterial hypertension, hemoptysis, or recurrent infections with bronchiectasis affecting the hypoplastic lung may necessitate hospital admission [9-11].

Radiological imaging typically reveals volume loss in the affected lobe or lung, mediastinal shift towards the hypoplastic side, volume increase in the contralateral lung or adjacent lobes, and elevation of the adjacent diaphragm [11,12]. CT scans are particularly effective for evaluating the diameter of tracheobronchial and major vascular structures, as well as extensive lung tissue damage, including damage to alveolar and bronchial structures. Hypoplastic bronchi can also be visualized on bronchoscopy [3].

Treatment in adults often involves conservative approaches such as managing infections, symptomatic relief with bronchodilators or expectorants, and prophylactic vaccination if necessary. However, in some patients, recurrent infections and cystic degeneration of the airways may necessitate surgical intervention, particularly if complications such as hemoptysis develop [5]. Minimally invasive surgical methods are preferred, with thoracotomy reserved for cases where thoracoscopic exposure is not feasible due to excessive adhesions [13]. In this patient, recurrent pulmonary infections and recent onset hemoptysis were the primary indications for surgical treatment, and bilateral thoracoscopic lower lobectomy was performed.

In conclusion, pulmonary hypoplasia is rare in adults and typically presents with recurrent lower respiratory tract infections and associated complications. Anatomical surgical resection is recommended using minimally invasive methods and/or thoracotomy

Declaration of conflicting interests

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Authors' contributions

MGP,VI,YB: conceived and designed the current case report, co-wrote the paper, collected the clinical data. The authors discussed the case under the literature data together and constituted the final manuscript.

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Case Report

Giant solitary fibrous tumor of the diaphragm supplied by aortic branches

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ABSTRACT

Solitary fibrous tumor is a rare neoplasm of mesenchymal origin and in the literature, few cases from the diaphragm, feeding on abdominal aortic branches is reported. Here we present a 51-year-old female patient with solitary fibrous tumor originating from the diaphragm.

Keywords: solitary fibrous tumor, neoplasm, diaphragm, thoracotomy

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Introduction

Solitary fibrous tumor (SFT) is a rare neoplasm of mesenchymal origin. Its incidence is equal in men and women, and it most often occurs between the ages of 50 and 80 [1]. SFTs constitute less than 5% of thoracic pleural tumors [2] and commonly occur in the visceral pleura. Also, SFTs of the diaphragm are even rarer [3]. In the literature, few cases of giant SFT originating from the diaphragm, feeding on abdominal aortic branches. We aimed to present a rare case with giant peduncle SFT originating from the diaphragm.

Case Report

A 51-year-old female patient, who was operated on one year ago for a liver hydatid cyst, was referred to the thoracic surgery clinic. Chest radiography appearance was compatible with a mass filling the middle and lower zones of the left hemithorax (Figure 1a). In contrast-enhanced computed tomography (CECT), a solid mass with smooth borders of 11×15×12 cm (TR×AP×CC) in size was detected in the left hemithorax, starting from the level of the upper lobe lingular segment, and filling the lower zone almost totally; the collateral arterial vascular structures associated with the left renal-phrenic artery showed a course and contains calcification and necrotic areas in some places (Figures 1b,c). Contrast-enhanced thoracic MRI was performed to evaluate invasion to neighboring structures more clearly. MRI showed a mass lesion with hypointense cystic and necrotic areas on T1A series, hyperintense cystic and necrotic areas on T2A series, no diffusion restriction on diffusion examination, no extension to the paravertebral area, no destruction of adjacent costae, and heterogeneous contrast uptake except for the cystic and necrotic area in the center.

The tru-cut biopsy result was reported as a lesion containing collagenized stroma and spindle cell areas. Patient's laboratory findings and tumor markers (CEA = 0.79 ng/mL, CA15-3 = 8.8 U/mL; CA19-9 = 14.1 U/mL; CA125 = 7.6 U/mL).were within the normal limits.

Surgery was performed with posterolateral thoracotomy. A mass was found adherent to the left lower lobe with an approximately 9 cm long peduncle, which was observed intraoperatively to originate from the left hemidiaphragm (Figures 2a,b). The portion of the diaphragm adjacent to the pedicle was resected. The mass was 16×20 cm in size and weighted 1450 gr (Figure 2c). After resection, the left lower lobe was not hypoplastic, filled the lower hemithorax.

Embolism protocol computed tomography was performed on patient who had complaints of dyspnea on the first postoperative day and pulmonary embolism findings were observed. Low–molecular weight heparin was started. The patient did not show any problems in clinical and radiological follow-ups and hence was discharged. In the postoperative immunohistochemical examination of the patient; neoplastic cells were positive with CD34, bcl2 and diffuse nuclear positive with STAT6 (Figure 3). Pancytokeratin, CD99, DESMIN, CD31, S100 were negative. The findings were reported as compatible with solitary fibrous tumor. Written informed consent was obtained from the patient for the publication of her data.

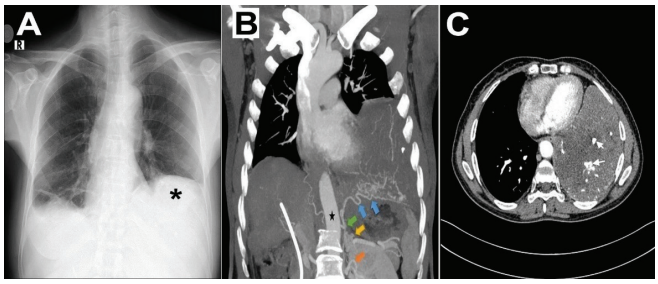

Figure 1. *Increased radiopacity due to a mass in the lower zone of the left hemithorax on chest X-ray **(A)**, orange arrow, left renal artery; yellow arrow, collateral suprarenal vascular structures; green arrow, left inferior phrenic artery originating from the abdominal aorta; blue arrow, collateral vascular structures associated with the left inferior phrenic arteries; star, aorta **(B)**, white arrow, a significant increase in vascularity seen in the mass in the axial section in CT **(C)**.

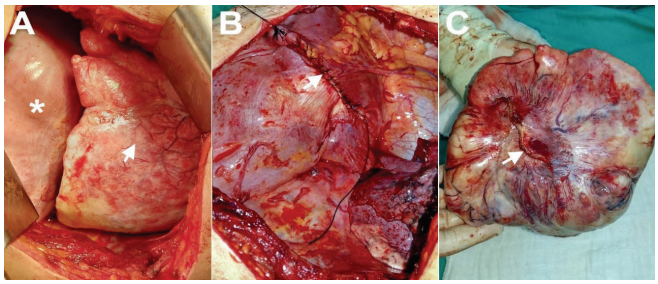

Figure 2. *Diaphragm, white arrow: mass **(A),** defect in the diaphragm **(B)**, white arrow: peduncle separating from the diaphragm on the lower face of the mass **(C)**.

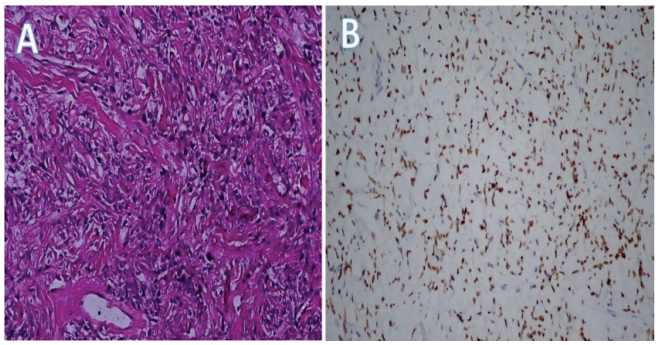

Figure 3. Appearance showing oval to spindle-shaped nuclei and cells with focal fascicular pattern, H&E X20 **(A)**, diffuse nuclear positivity with STAT6 in immunohistochemical staining, STAT6 X20 **(B)**.

Discussion

SFTs are rare tumors that grow from mesenchymal connective tissue and originate from spindle cells. Although massive spindle cell tumors have been reported in the pleural space measuring 27×20×15 cm and weighing 2470 gr) [4], only a few comprehensive SFT presentations of the diaphragm origin have been discovered, as in our present case [3,5]. According to the 2015 World Health Organization classification, malignant SFTs are usually larger than 10 cm and comprise more than 4 per 2 mm2 of mitosis, hypercellularity, necrosis/hemorrhage, and nuclear pleomorphism. Mitosis–necrosis ratio is an important indicator of malignancy. Although the tumor, in this case, was 16×20 cm in size and weighed 1450 gr, it was classified as a predominantly diaphragmatic, benign, solitary fibrous tumor with no significant atypia or mitotic pleomorphism. Besides, the capsule was smooth and connected to the diaphragm with a peduncle. Moreover, while tumor marker levels are expected to be high in malignant SFTs(CA 72, 419.9 U/mL; CA 125, 525.6 U/mL) [5], tumor marker levels(CEA, 0.79 ng/mL; CA 15-3, 8.8 U/mL; CA 19-9, 14.1 U/mL; CA 125, 7.6 U/mL) were within normal limits in the current case. According to Karen Harrison-Phipps et al (2009) [6], the probability of malignancy increases as the tumor size grows. Normal tumor markers and well-circumscribed mass capsules, as in our case, may indicate that SFT, regardless of size, is benign.

In the present case, CECT showed that the mass was supplied by diffuse tortuous collateral arterial structures originating from the abdominal aorta, related to the left phrenic artery and left renal artery. Capsular integrity must be preserved and more careful dissection should be performed in cases with aortic blood supply. Also, lung dissection is recommended after separating the peduncle and controlling the arterial feeding in SFTs, whose blood supply comes from the systemic circulation.

In conclusion, to the best of our knowledge, this is one of the few cases of giant peduncle SFT originating from the diaphragm that was feeding on the abdominal aorta in the English literature. In such cases, en-bloc surgical resection is currently accepted as the universal treatment method. Complete resection provides the best survival in malignant and benign cases. Therefore, surgery is recommended without wasting time after the detection of SFTs originating from the diaphragm.

Declaration of conficting interests

The authors declared no conficts of interest with respect to the authorship and/or publication of this article.

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Authors' contributions

HEC,SEA,VAA,RY,ID: conceived and designed the current case report, co-wrote the paper, collected the clinical data. The authors discussed the case under the literature data together and constituted the final manuscript.

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Current Thoracic Surgery

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Case Report

Lung-sparing procedure in delayed period pulmonary artery coil migration: case presentation

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ABSTRACT

Sur Coil stands out as one of the most widely utilized agents for vascular embolization. While the occurrence of coil migration into the pulmonary artery is an infrequent event, the approach to treatment varies based on the duration between the procedure and the appearance of symptoms, as well as the specific symptoms exhibited. In this particular case, we share an instance where surgical intervention was conducted at the age of 41 due to coil migration, emphasizing the preservation of lung parenchyma. It is noteworthy that, even in the later stages, the secure removal of the coil can be achieved through surgical procedures designed to safeguard the lung tissue. I am confident that this lung-preserving approach represents a commendable strategy for such cases.

Keywords: pulmonary, surgery, coil, migration, lung-sparing,

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Introduction

Vascular malformations are primarily addressed through interventional radiological procedures, benefitting from their diminished invasiveness and lower complication rates, attributed to advancements in angiography and associated technologies. Nevertheless, the infrequent event of migration of the commonly utilized embolic agent, the coil, may be encountered during the procedure. The approach to follow-up and treatment can vary, considering the patient's symptoms, findings, and the duration elapsed since the intervention [1,2].

In this context, we present a case where coil embolization was initially applied for an external iliac vein aneurysm. Subsequently, surgical intervention became necessary due to the migration of the coil into the pulmonary artery.

Case Report

A male patient, aged 41, underwent coil embolization six years ago for a 5 cm aneurysm in the left external iliac vein, performed by interventional radiology. The patient remained symptom-free until a year ago when he started experiencing cough and shortness of breath. Diagnostic tests revealed a foreign object resembling a coil in the anterior branch of the left pulmonary artery trunk (Figure 1). Subsequently, the patient was referred to our clinic. During the patient's history, it was mentioned that five coils were used for the iliac vein, but post-procedural images were unavailable. As a result, the existing image was assumed to represent the coil.

The patient was initially referred to the interventional radiology clinic, and due to the six-year interval since the procedure, the anticipation of epithelialization and the high risk of complications led to the decision to forgo further interventional procedure. A surgical approach was chosen, and entry into the thoracic cavity was achieved through a left lateral thoracotomy incision. Complete dissection of the pulmonary artery allowed for the visualization of the anterior trunk. Irregular and rigid characteristics were noted along the wall of the anterior trunk from its origin in the pulmonary artery. Palpation revealed an object consistent with a foreign body along a 2cm length of the anterior trunk. Vascular clamps were applied proximally and distally to control the pulmonary artery. The anterior trunk was longitudinally opened, exposing the foreign body. Using forceps, the foreign body was successfully extracted (Figure 3). Intraoperative fluoroscopy revealed the presence of a residual coil within the anterior trunk artery. Consequently, the dissection of the anterior trunk was extended to locate and remove a second coil. Subsequently, the anterior trunk was primarily sutured and closed longitudinally. The lengths of the coils were measured as 1.5 meters for the first segment and 4.5 meters for the second segment (Figure 4).

During intraoperative assessment, an epithelized coil fragment of up to 5 mm was observed within the vascular structure, and no additional intervention was deemed necessary. Follow-up chest X-rays did not reveal any additional findings aside from the 5 mm linear coil along the vessel wall (Figure 4). The patient, who underwent intraoperative heparinization and continued anticoagulant therapy postoperatively, was monitored with a drainage tube for 10 days due to hemorrhagic drainage. Afterward, the drainage tube was removed, and the patient was discharged in a healed condition. Subsequent follow-ups at the 6th month showed a complete resolution of symptoms, with no additional complaints observed. Furthermore, when the patient's respiratory function test was evaluated comparatively preoperatively and postoperatively, an increase in respiratory capacity was noticeable despite the thoracotomy. Written informed consent was obtained from the patient for the publication of his data.

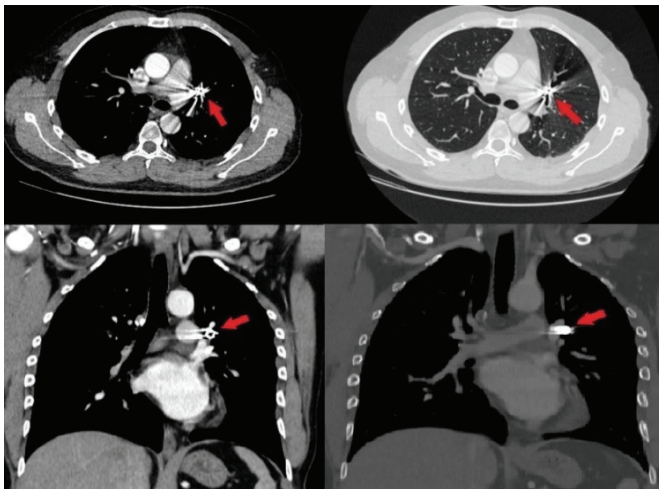

Figure 1. Thorax CT view of the coil migration.

Figure 2. Intraoperative view of coil removal.

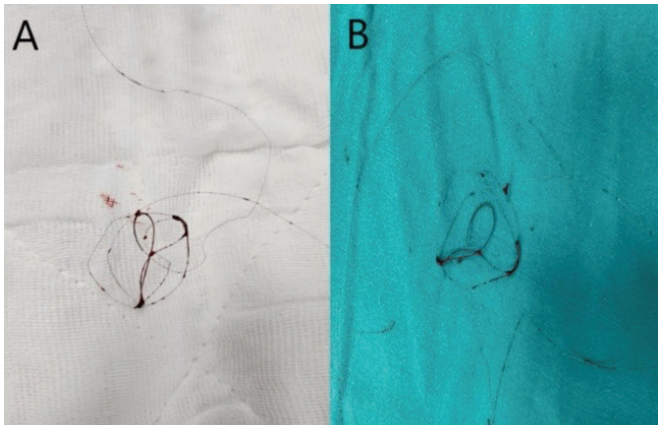

Figure 3. Coil part removed in the first stage **(A)**, coil part removed in the second stage **(B)**.

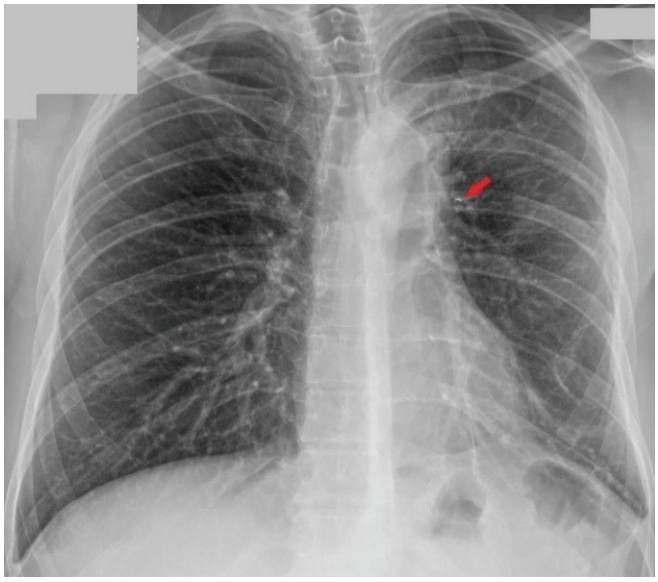

Figure 4. Postoperative chest X-ray with residual coil.

Discussion

The use of coil embolization has been actively employed since its efficacy was proven in 1975. The primary advantage of this procedure is its less invasive nature compared to surgical interventions, resulting in fewer complications. A coil is a material created by interweaving two wires, and its shape and covering can vary depending on the materials used. With its shape memory, it fills the structure from the moment it is withdrawn from the catheter, leading to vascular occlusion [1].

One of the significant complications of coil embolization is coil migration. The most crucial risk factor for incorrect placement is reported to be the mismatch between the aneurysm area to be embolized and the coil diameter. Although the migration rate is reported in the literature as 0.7-4%, and misplaced coils have been shown to reach various target organs, placement in the pulmonary artery is emphasized to be quite rare. Since most cases do not result in end-organ damage and remain asymptomatic in different organ placements, additional interventional procedures are generally not required [1].

Reviewing cases of coil misplacement in the pulmonary artery in the literature, it is observed that different principles were adopted in almost all cases. In two cases where a coil misplaced immediately after the procedure was detected, the decision for follow-up was made due to the absence of active complaints, no decrease in saturation, and no development of hypotension. The patient was successfully monitored without the need for additional interventions [1,3].

In another case, a patient who underwent coil embolization for pelvic congestion syndrome three months ago developed sudden pleuritic pain, dyspnea, and orthopnea. After excluding diseases such as pneumothorax and pulmonary thromboembolism through differential diagnosis, coil misplacement in the pulmonary artery branch was detected. Due to the patient's active complaints and the short time elapsed since the procedure, a less invasive intervention was performed to remove the coil through interventional vascular procedures. Although a residual small coil fragment was reported, the procedure was terminated due to the regression of active symptoms and the increased risk of complications. The patient was successfully monitored [2].

In yet another case, coil embolization was performed three years ago, and in a patient with a cough complaint for two months, coil misplacement in the pulmonary artery was detected. The coil was removed along with a lower lobectomy, and surgical resection was primarily chosen because the procedure had taken place for an extended period, making epithelialization and invasion into the vessel wall highly probable [4].

In our case, the decision for surgical intervention instead of follow-up was primarily due to the patient's newly developed dyspnea, with no additional pathology detected apart from coil migration explaining the existing complaint. Opting for a less invasive procedure, such as interventional radiological procedures, over surgery aligns with the literature, correlating with the time elapsed since the procedure and the increased risk of coil invasion into the vessel wall and complications. Similar to the case presentation, a residual coil fragment remained in our study, but due to the regression of active symptoms and the potential for increased complications, the procedure was terminated, and the patient was successfully monitored.

Coil migration is a rare occurrence. Especially the performance of coil removal with interventional vascular procedures in the early period and the combined proce-

dure with lung resection in the late period are much rarer. In our case, as observed in the literature, lung-preserving surgical procedures can be successfully performed even in a chronic process. In cases with coil migration, according to the literature, additional interventions are not planned for asymptomatic cases during follow-ups. However, as in our case, it can lead to additional symptoms years later, so one should remain vigilant.

In conclusion, although pulmonary artery coil migration can rarely be observed after interventional vascular embolization, the general approach in the early period is removal through vascular interventional methods, and in the late period, surgical resection is considered if it causes symptoms and signs. As in our case, lung-preserving surgical procedures can be successfully applied even in a chronic process.

Declaration of conficting interests

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Authors' contributions

MÇ;MB;FS;KA: conceived and designed the current case report, co-wrote the paper, collected the clinical data. The authors discussed the case under the literature data together and constituted the final manuscript.

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Case Report

Simultaneous excision of intrathoracic solitary fibrous tumor and retroperitoneal schwannoma with robot-assisted surgery

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ABSTRACT

Pleural solitary fibrous tumor is a rare neoplasms of the thoracic cavity. Retroperitoneal schwannomas are typically benign, solitary and encapsulated lesions. A previously healthy 39-year-old female patient was examined due to prolonged menstruation. The examination of the patient incidentally revealed two rare neoplasms both in the thoracic cavity and in the retroperitoneal space. The patient underwent simultaneous robot-assisted excision of intrathoracic solitary fibrous tumor and retroperitoneal schwannoma. This case emphasizes that simultaneous robot-assisted surgery for the resection of small masses in the posterior mediastinum and retroperitoneal region may be appropriate in selected patients.

Keywords: solitary fibrous tumor, robot asisted surgery, schwannoma

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Introduction

Solitary fibrous tumor (SFT) is a rare spindle cell tumor of mesenchymal origin that first described by Klemperer et al [1]. Most of the benign SFTs originate from the visceral pleura and usually extend into the pleural cavity. These lesions, which can also be seen in various extrapleural thoracic locations, including the pericardium, heart, lungs and mediastinum, affect men and women equally [2]. They are usually asymptomatic and the diagnosis is mostly incidental. Chest X-ray, computed tomography (CT), magnetic resonance imaging (MRI), positron emission tomography (PET) are helpful in diagnosis. The current standard approach is curative surgery which aimed the complete resection of the tumor that provides the best prognosis [3].

Schwannomas are rare, typically benign, solitary and encapsulated lesions. These benign neoplasms originating from Schwann cells of the peripheral nerve sheath represent less than 1% of all primary retroperitoneal tumors [4]. Radical resection without disrupting the integrity of the capsule is the mainstay of treatment for primary retroperitoneal schwannomas, otherwise recurrence has been reported in 5-10% of cases [5].

In this article, a simultaneous excision of intrathoracic solitary fibrous tumor and retroperitoneal schwannoma using the robot-assisted system.

Case Report

A previously healthy 39-year-old female patient was examined due to prolonged menstruation. She was a nonsmoker with no significant medical history. Physical examination was within normal limits. In the abdominal MRI scan, a 23 mm solid lesion was observed adjacent to the lower pole of the left kidney (Figure 1). Additionally a mass measuring 44 × 35 mm in the right paravertebral area was also seen in this scan. A simultaneous minimally invasive surgery for excision of both lesions was planned.

In the first stage, four robotic trocars were placed after the patient was positioned the left flank. After docking, the robotic arms were connected to the trocars and the instruments were placed in the abdomen. The Toldt line was incised and the intestinal structures were medialized and removed from the operation line. Gerato's fascia and kidney lower pole were observed. A solid mass with a size of 2.5 × 2 cm was seen in the Gerato's facia, separate from the kidney tissue. Total excision was performed with the appropriate surgical margins and without deterioration of capsule integrity. Afterwards, the patient was placed in the left lateral decubitus position, and a total of four port incisions were made in the right hemithorax, three for robotic arms and one for the assistant surgeon (Figure 2). Robotic arms were installed. On exploration, a mass approximately 4 cm in diameter with a paravertebral location was detected at the T8 level (Figure 3). The mass was completely excised (Figure 4). Total operation time was 280 minutes, and the total blood loss was 100 ml in both surgery. The patient was mobilized immediately after the operation. After an uneventful postoperative period the patient was discharged two days after surgery.

In the histopathological examination, the mass excised from the retroperitoneal region measured 2.5 × 2 × 2 cm and was evaluated as a schwannoma. Immunohistochemically, S-100 was positive and CD34 was negative. The intrathoracic excised mass measured 4.5 × 3.5 × 3 cm in diameters and was reported as a solitary fibrous tumor. Immunohistochemical examination of SFT revealed CD34 (+), EMA and S-100 (-). No recurrence was observed at the 3-years follow-up. Written informed consent was obtained from the patient for the publication of her data.

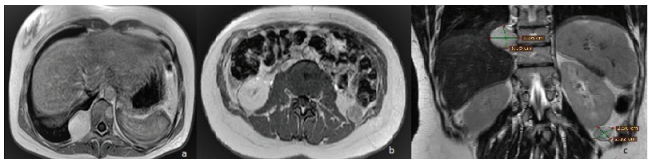

Figure 1. MRI scan of the lesions showing; intrathoracic mass **(a)**, retroperitoneal mass **(b)**, both masses **(c)**.

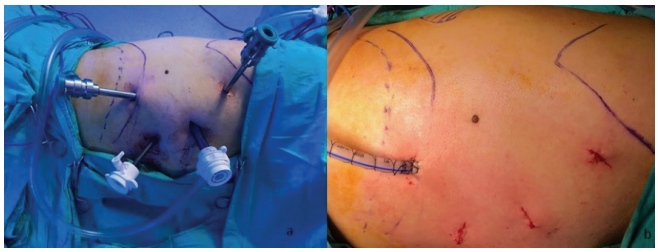

Figure 2. Placement of thorocars in robot-assisted thoracic Surgery **(a)**, postoperative view of port and drain locations **(b)**.

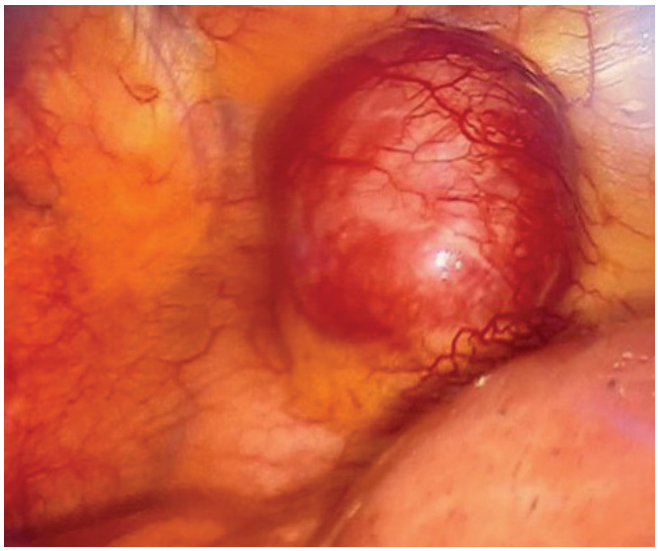

Figure 3. Intrathoracic view of the thoracic mass.

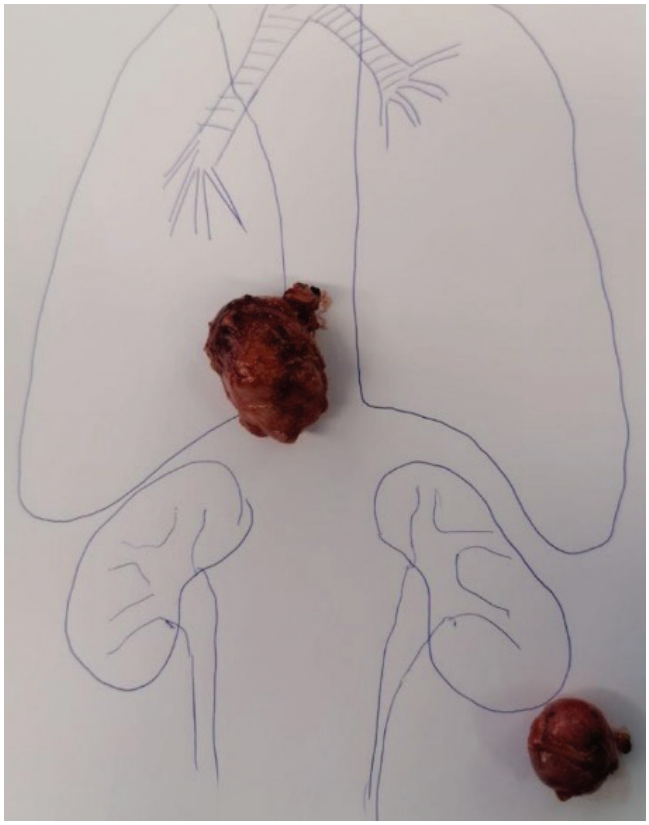

Figure 4. Schematic view of both masses.

Discussion

Solitary fibrous tumors generally appear as whitish, well-circumscribed and encapsulated lesion. In our case, the excised mass exactly corresponds to the macroscopic features that described in the literature. When it is located in the intrathoracic cavity, 80% of them originates from the visceral pleura. The mass we excised, on the other hand, arises from the parietal pleura, which is rare. In immunohistochemical evaluation of our case, CD34 was positive and S-100 was negative which supports that this lesion was benign because it is revealed that CD34 expression was negative approximately 90% of malignant SFTs [6].

In a review article including ten studies, the recurrence rate of benign solitary fibrous tumors was reported as 3% [7]. In our case, no recurrence was detected at three-year follow-up.

The minimally invasive approach has become the golden standard in many surgical branches, including thoracic surgery. Ghanim et al emphasized that video-assisted thoracic surgery (VATS) is the most commonly used minimally invasive technique in the treatment of small sized intrathoracic SFTs, compared to open surgery [8]. Robot-assisted surgery is also an important minimally invasive surgical technique. The advantages of this system are that it allows three-dimensional (3D) imaging, the surgeon's tremor is not reflected in the robotic arm movements, and simultaneously it provides more freedom of movement with multi-jointed robotic arms. Similar morbidity rates and length of hospitalization are observed by robot-assisted surgery compared to VATS in the resection of mediastinal tumors and cysts [9]. No complications were observed after robot-assisted surgery in our patient.

Schwannoma originating from Schwann cells of peripheral or cranial nerves is encountered in the retroperitoneal space in only 0.5% of cases [10]. The majority of patients are often asymptomatic or may present with nonspecific and vague symptoms, as in our case, and it is detected incidentally. It is difficult to make a definitive diagnosis in the preoperative period, especially due to it is rare occurrence in the retroperitoneal region. Macroscopically, retroperitoneal schwannomas are encapsulated and well-circumscribed tumors. In this case, the excised material was also encapsulated, shiny in appearance and orange in color on sections. In the immunohistochemical examination, the generally accepted S-100 positivity was also detected in our case.

The prognosis of schwannomas excised from the retroperitoneal region is generally satisfactory and recurrence is seen in 5-10% of patients probably due to inadequate excision [11]. In our case, no recurrence was observed during the 3-years follow-up period.

Robot-assisted surgery allows easier dissection, vessel ligation and suturing when compared to laparoscopic surgery. Consequently, a significant reduction in the intraoperative blood loss was observed with the robotic approach in dissection of deep tissues such as the retroperitoneal region. We did not encounter any bleeding after the simultaneous surgery we performed. As reported in some studies, the most important disadvantages of robotic surgery are longer mean operation time and higher cost compared to laparoscopy [12].

Despite the widespread use of robot-assisted surgery, especially in recent years, and oncological surgeries being increasingly performed with this technique, we have not encountered a case of simultaneous excision of intrathoracic and retroperitoneal masses with this technique in the literature. Principally, in these cases, two-stage surgery (the first treatment is for the more aggressive lesion) is performed as a treatment plan. The advantage of treating two neoplasms simultaneously is to avoid delaying treatment of the second tumor, especially in young patients. Possible problems can be listed when the treatment is performed in two stages include delay in excision of other masses due to waiting for the postoperative healing phase after the first surgery and intermittent anesthesia. This results, in turn, leads to an increase in cost and in the duration of hospitalization.

In conclusion, simultaneous minimally invasive surgery for small masses in the posterior mediastinum and retroperitoneal region may be appropriate in selected patients. Robotic-assisted surgery can be an alternative minimally invasive technique to VATS because of its technical superiorities. The only disadvantage of both robotic assisted surgery and simultaneous operation is prolonged operation time.

Declaration of conficting interests

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Authors' contributions

SM;TÇ;ÖS;ÖÇ;MŞ: conceived and designed the current case report, co-wrote the paper, collected the clinical data. The authors discussed the case under the literature data together and constituted the final manuscript.

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Decleration of sponsorship

The authors should describe the role of the study's sponsors in the following areas: a. designing the study, b. collecting, analyzing, and interpreting the data, c. writing the report.

Corrections, Retractions and Expression of Concern

It is presumed that manuscripts report on work based on honest observations. However occasionally information becomes available with may contradict this. In such situations CTS apply Committee on Publication Ethics guidelines on corrections, retractions and expressions of concern.

Corrections

Errors in published papers may be identified requiring publication of a correction in the form of a corrigendum or erratum. Because articles can be read and cited as soon as they are published, any changes thereafter could potentially impact those who read and cited the earlier version. CTS provides authors with an opportunity to review article proofs prior to publication with the express goal of ensuring accuracy of the content. Publishing an erratum or corrigendum increases the likelihood readers will find out about the change and also explains the specifics of the change.

Corrigenda and Errata will be published on a numbered page and will contain the original article's citation. Cases where these corrections are insufficient to address an error will be dealt with on a case-by-case basis by the Editor in Chief. Inadequacies arising from the normal course of new scientific research are not within the scope of this and will require no correction or withdrawal.

Article retraction

Infringements of professional ethical codes, such as multiple submission, bogus claims of authorship, plagiarism, fraudulent use of data or the like. Occasionally a retraction will be used to correct errors in submission or publication. The retraction of an article by its authors or the editor under the advice of members of the scholarly community has long been an occasional feature of the learned world. Standards for dealing with retractions have been developed by a number of library and scholarly bodies, and this best practice is adopted for article retraction by CTS:

A retraction note titled "Retraction: [article title]" signed by the authors and/or the editor will be published in the paginated part of a subsequent issue of the journal and listed in the contents list. In the electronic version, a link will be made to the original article. The online article will preceded by a screen containing the retraction note. It is to this screen that the link resolves; the reader can then proceed to the article itself. The original article will be retained unchanged save for a watermark on the .pdf indicating on each page that it is "retracted."

Article removal

In an extremely limited number of cases, it may be necessary to remove an article from the online database. This will only occur where the article is clearly defamatory, or infringes others' legal rights, or where the article is, or we have good reason to expect it will be, the subject of a court order, or where the article, if acted upon, might pose a serious health risk. In these circumstances, while the metadata (Title and Authors) will be retained, the text will be replaced with a screen indicating the article has been removed for legal reasons.

Article replacement

In cases where the article, if acted upon, might pose a serious health risk, the authors of the original article may wish to retract the flawed original and replace it with a corrected version. In these circumstances the procedures for retraction will be followed with the difference that the database retraction notice will publish a link to the corrected re-published article and a history of the document.

Expressions of concern

Where substantial doubt arises as to the honesty or integrity of a submitted or published article it is the Editor in Chief's responsibility to ensure that the matter is adequately addressed, usually by the authors' sponsoring institution. It is not normally the Editor in Chief's responsibility to carry out the investigation or make a determination. The Editor in Chief should be promptly informed of the decision of the sponsoring institution and a retraction printed should it be determined that a fraudulent paper was published. Alternatively, the Editor in Chief may choose to publish an expression of concern over aspects of the conduct or integrity of the work.

Withdrawal

Articles may be withdrawn by corresponding author before accepting for publication. If it is accepted, it could be used only for Articles in Press which represent early versions of articles and sometimes contain errors, or may have been accidentally submitted twice. Occasionally, but less frequently, the articles may represent infringements of professional ethical codes, such as multiple submission, bogus claims of authorship, plagiarism, fraudulent use of data or the like. Articles in Press (articles that have been accepted for publication but which have not been formally published and will not yet have the complete volume/issue/page information) that include errors, or are discovered to be accidental duplicates of other published article(s), or are determined to violate our journal publishing ethics guidelines in the view of the editors (such as multiple submission, bogus claims of authorship, plagiarism, fraudulent use of data or the like), may be "Withdrawn" from CTS. Articles which have been published under an issue could not be withdrawn.

Responding to Allegations of Possible Misconduct (Explicit Policy)

All allegations of misconduct will be referred to the Editor-In-Chief, who will review the circumstances in consultation with the deputy editors. Initial fact-finding will usually include a request to all the involved parties to state their case, and explain the circumstances, in writing. In questions of research misconduct centring on methods or technical issues, the Editor-In-Chief may confidentially consult experts who are blinded to the identity of the individuals, or if the allegation is against an editor, an outside editor expert. The Editor-In-Chief and deputy editors will arrive at a conclusion as to whether there is enough evidence to lead a reasonable person to believe there is a possibility of misconduct. Their goal is not to determine if actual misconduct occurred, or the precise details of that misconduct.

When allegations concern authors, the peer review and publication process for the manuscript in question will be halted while the process above is carried out. The investigation described above will be completed even if the authors withdraw their paper, and the responses below will still be considered. In the case of allegations against reviewers or editors, they will be replaced in the review process while the matter is investigated. For further information visit "Useful links".

Data Sharing Policy

Current Thoracic Surgery requires authors to submit a data-sharing statement form and register a data-sharing plan when registering a clinical trial. The ICMJE's data sharing statement policy asks authors to submit a data-sharing statement for randomized clinical trials. The ICMJE's policy regarding trial registration is explained at (http://www.icmje.org/icmje-recommendations.pdf).

Accordingly, the data sharing statements must indicate the following:

whether individual deidentified participant data (including data dictionaries) will be shared,

what data in particular will be shared,

whether additional, related documents will be available (e.g., study protocol, statistical analysis plan, etc.),

when the data will become available and for how long,

by what access criteria data will be shared (including with whom, for what types of analyses, and by what mechanism).

Authors must provide a data-sharing statement at submission to indicate whether data will be shared according to the statements written above.

Please visit http://www.icmje.org/icmje-recommendations.pdf that provides illustrative examples of data sharing statements that would meet these requirements.

Authors of secondary analyses using shared data must attest that their use was in accordance with the terms (if any) agreed to upon their receipt. They must also reference the source of the data using its unique, persistent identifier to provide appropriate credit to those who generated it and allow searching for the studies it has supported. Authors of secondary analyses must explain completely how theirs differ from previous analyses. In addition, those who generate and then share clinical trial data sets deserve substantial credit for their efforts. Those using data collected by others should seek collaboration with those who collected the data. As collaboration will not always be possible, practical, or desired, the efforts of those who generated the data must be recognized.

Statistical Knowledge

The statistical method used should be reported in a way that a reader whoever could reach the original data could understand the results. The terms used, abbreviations, symbols, the pc programme used and the statistical method should all be defined.

When reporting the results, especially when giving means and percentages, two digits should be given after the comma (112.20 or 112.21 instead of 112.2). P, t, Z values are exceptional and three digits should be given after the comma ($p = 0{,}001$, instead of $p < 0{,}05$).

Briefly, except whole numbers, two digits after the comma should be given, but for statistical values like p,t,z,F,Chi-square, three digits after the comma should be given. When presenting p values, the exact p value together with the test statistics should be given, except for the case when this value is smaller than one percent or one per thousand (this time $p < 0.01$ or $p < 0.001$, respectively should be given).

Preparation of Manuscript

Cover Letter

The Current Thoracic Surgery requires authors to disclose in the "cover letter" any commercial association (eg, employment, direct payments, stock holdings, retainers, consultantship, patent licensing arrangements, or honoraria) that might pose a conflict of interest issue concerning the manuscript. All funding sources supporting the work should be acknowledged in a footnote. Also authors should mention that none of the material in the manuscript has been published previously, and that none of this material is currently under consideration for publication elsewhere. This includes symposia, transactions, books, articles published by invitation, and preliminary publications of any kind except an abstract of 400 words or fewer.

Style and Format

Manuscripts should be double-spaced with 3-cm margins on all sides of the page, in Times New Roman font. Every page of the manuscript, including the title page, references, tables, etc., should be numbered. All copies of the manuscript should also have line numbers starting with 1 on each consecutive page.

Symbols, Units and Abbreviations

In general, the journal follows the conventions of Scientific Style and Format, The CSE Manual for Authors, Editors, and Publishers, Council of Science Editors, Reston, VA, USA (7th ed.). If symbols such as ×, μ, η, or ν are used, they should be added using the Symbols menu of Word. Degree symbols (°) must be used from the Symbol menu, not superscripted letter o or number 0. Multiplication symbols must be used (×), not the letter x. Spaces must be inserted between numbers and units (e.g., 3 kg) and between numbers and mathematical symbols (+, –, ×, =, <, >), but not between numbers and percent symbols (e.g., 45%). Please use SI units. All abbreviations and acronyms should be defined at first mention. Latin terms such as et al., in vitro, or in situ should not be italicized.

Manuscript Content

Research articles should be divided into the following sections. Principal sections should be Introduction, Materials and Methods, Results, Discussion, Acknowledgements and References sections. Please see below for information about other types of manuscripts.

Title and Contact Information

The first page should contain the full title in sentence case, the full names (last names fully capitalized) and affiliations (in English) of all authors (University, Faculty, Department, City, Country), and the contact address and e-mail for the clearly identified corresponding author.

Abstract

An informative abstract of not more than 250 words must accompany each manuscript. The abstract must be structured to include the study's background, materials and methods, results, and conclusions and key words under 5 separate headings. Abstracts of review articles should be a brief overview of the main points from the review.

Keywords

Please provide at least 3 key words or phrases to enable retrieval and indexing. Acronyms should be avoided.

Always try to use terms from the Medical Subjects Headings (MeSH) list from PubMed https://www.ncbi.nlm.nih.gov/pubmed.

Introduction

This should argue the case for your study, outlining only essential background, and should not include the findings or the conclusions. It should not be a review of the subject area, but should finish with a clear statement of the question being addressed.

Materials and Methods

Explain clearly but concisely your clinical, technical, or experimental procedures. Previously published papers related to the methods should be cited with appropriate references. Brand names and company locations should be supplied for all mentioned equipment, instruments, chemicals, etc.

Results

Findings must be described without comment. The same data or information given in a Table must not be repeated in a Figure and vice versa. It is not acceptable to repeat extensively the numbers from Tables in the text or to give lengthy explanations of Tables or Figures.

Discussion

Statements from the Introduction and Results sections should not be repeated here. The final paragraph should highlight the main conclusions of the study. Names of funding organizations should be written in full.

References

In the text, references should be identified using numbers in square brackets in which they appear consecutively. The titles of journals should be abbreviated according to the style used in Index Medicus. Ageneral guide limit the number of references to 25 for original articles, to 6 for case reports and to 85 for reviews. For articles with 1 to 6 authors, list all authors. For articles more than 6 authors, list the first 6 authors followed by "et al.". Do not use individual sets of parentheses for citation numbers that appear together, e.g., [2,3,5-9], not [2],[3],[5]–[9]. For other styles of publication or Internet articles, see http:// www. nlm.nih.gov/ bsd/ uniform_requirements.html References should be formatted as follows (please note the punctuation and capitalization)

Journal titles should be abbreviated according to ISI Web of Science abbreviations. Authors are solely responsible for the accuracy and completeness of references.

Articles in Journals

Özpolat B, Gürpınar ÖA, Ayva EŞ, Gazyağcı S, Niyaz M. The effect of Basic Fibroblast Growth Factor and adipose tissue derived mesenchymal stem cells on wound healing, epithelization and angiogenesis in a tracheal resection and end to end anastomosis rat model. Turk Gogus Kalp Dama 2013; 21: 1010-9.

For other styles of publication or Internet articles, see http:// www.nlm.nih.gov/bsd/uniform_requirements.html

Tables and Figures

All illustrations (photographs, drawings, graphs, etc.), not including tables, must be labeled "Figure." Figures must be submitted both in the manuscript and as separate files.

All tables and figures must have a caption and/or legend and be numbered (e.g., Table 1, Figure 2), unless there is only one table or figure, in which case it should be labeled "Table" or "Figure" with no numbering. Captions must be written in sentence case (e.g., Macroscopic appearance of the samples.). The font used in the figures should be Times New Roman. If symbols such as ×, μ, η, or ν are used, they should be added using the Symbols menu of Word.

All tables and figures must be numbered consecutively as they are referred to in the text. Please refer to tables and figures with capitalization and unabbreviated (e.g., "As shown in Figure 2…", and not "Fig. 2" or "figure 2"). The tables and figures themselves should be given at the end of the text only, after the references, not in the running text.

The resolution of images should not be less than 118 pixels/cm when width is set to 16 cm. Images must be scanned at 1200 dpi resolution and submitted in jpeg or tiff format. Graphs and diagrams must be drawn with a line weight between 0.5 and 1 point.

Graphs and diagrams with a line weight of less than 0.5 point or more than 1 point are not accepted. Scanned or photocopied graphs and diagrams are not accepted.

Charts must be prepared in 2 dimensions unless required by the data used. Charts unnecessarily prepared in 3 dimensions are not accepted.

Figures that are charts, diagrams, or drawings must be submitted in a modifiable format, i.e. our graphics personnel should be able to modify them. Therefore, if the program with which the figure is drawn has a "save as" option, it must be saved as *.ai or *.pdf. If the "save as" option does not include these extensions, the figure must be copied and pasted into a blank Microsoft Word document as an editable object. It must not be pasted as an image file (tiff, jpeg, or eps) unless it is a photograph.

Tables and figures, including caption, title, column heads, and footnotes, must not exceed 16×20 cm and should be no smaller than 8 cm in width. For all tables, please use Word's "Create Table" feature, with no tabbed text or tables created with spaces and drawn lines. Please do not duplicate information that is already presented in the figures.

Tables must be clearly typed, each on a separate sheet, and double-spaced. Tables may be continued on another sheet if necessary, but the dimensions stated above still apply.

Instruction to Reviewers

The Current Thoracic Surgery is a current periodical, peer-reviewed and open access official e- journal of the Turkish Society of Thoracic Surgery which its funded and published three times annually. In April, August and December.

The language of the journal is English.

The Current Thoracic Surgery is dedicated to publishing clinical research, clinical analysis, laboratory and experimental studies, editorials, invited current reviews, case reports, interesting images and "How to Do It" papers.

The journal is based on independent and unbiased double-blinded peer-reviewed principles. Only unpublished papers that are not under review for publication elsewhere can be submitted. Current Thoracic Surgery does not accept multiple submission and duplicate submission even though the previous one was published in a different language. The authors are responsible for the scientific content of the material to be published. The Current Thoracic Surgery reserves the right to request any research materials on which the paper is based.

The Current Thoracic Surgery encourages and enables academicians, researchers, specialists to publish their valuable research in branches of general thoracic surgery, thoracic disease and thoracic surgery anesthesia. The primary aim of the journal is to publish original articles with high scientific and ethical quality and serve as a good example of medical publications in the World.

The Editorial Board of the Current Thoracic Surgery and the Publisher adheres to the principles of the International Council of Medical Journal Editors (ICMJE), the World Association of Medical Editors (WAME), the Council of Science Editors (CSE), the Committee on Publication Ethics (COPE), the US National Library of Medicine (NLM), the World Medical Association (WMA), the US Office of Research Integrity (ORI), the European Association of Science Editors (EASE), and the International Society of Managing and Technical Editors (ISMTE).

All articles are available in PDF format on our website (www.http://cts.tgcd.org.tr/) and can be downloaded free of charge.

All articles submitted for publication are strictly reviewed for their

originality,

methodology,

importance,

quality,

ethical nature and,

suitability for the journal

The Current Thoracic Surgery uses a well-constructed scheme for the evaluation process.

The overall rejection rate of the Current Thoracic Surgery is 29%.

The average time during which the preliminary assessment of manuscripts is conducted is 4 days.

The average time during which the reviews of manuscripts are conducted is 41 days.

The average time in which the article is accepted for publication is 59 days.

The entire submission process for a manuscript is completed online through the self-explanatory online submission system.. The reviewers can reach their personal pages from the same address with their own passwords.

Manuscripts that comply with the main rules of the journal are sent to at least two external reviewers, and the reviewers are asked for their opinion about the suitability of the paper for publication. The reviewed manuscripts are then re-reviewed by the Editor in Chief and the Editorial Board and a decision of rejection or acceptance is shaped.

If the reviewers have any **potential competing interests**, they must notify the editor before agreeing to review a submission.

The Current Thoracic Surgery is committed to the highest standards of **research and publication ethics**. Editors will act in accordance with the relevant international rules of publication ethics (i.e., COPE guidelines, ICMJE Recommendations, CSE White Paper on Publication Ethics, CSE White Paper on Publication Ethics, WAME resources, WMA policies and ORI) if any ethical misconduct is suspected. The Editorial Board of the Current Thoracic Surgery encourages reviewers to comment on possible research or publication misconduct such as unethical research design, duplication, plagiarism, etc.

Plagiarism is a serious problem and the most common ethical issue afflicting medical writing. Current Thoracic Surgery does not allow any form of plagiarism. In accordance with our journal policy, submitted manuscripts are screened with plagiarism software to detect instances of overlapping and similar text (iThenticate and others) at least two times (during the evaluation process and after acceptance). If the reviewers have any suspect, the editors can provide them information obtained by plagiarism screening tools.

An **approval of research protocols by an ethics committee** in accordance with international agreements ("WMA Declaration of Helsinki - Ethical Principles for Medical Research Involving Human Subjects (last updated: October 2013, Fortaleza, Brazil)", "Guide for the care and use of laboratory ani-

mals (8th edition, 2011)" and/or "International Guiding Principles for Biomedical Research Involving Animals (2012)" is required for all research studies. If the submitted manuscript does not include ethics committee approval, it will be reviewed according to COPE's guideline (Guidance for Editors: Research, Audit and Service Evaluations). If the study should have ethical approval, authors will be asked to provide ethical approval. If they cannot provide ethical approval, their manuscript will be rejected and also their institutions and when needed, the related bodies in their country will be informed that such studies must have ethics committee approval. If the study does not need ethics committee approval after the editorial board's review, the authors will be asked to provide an ethics committee approval or a document given by a related independent committee that indicates the study does not need ethics committee approval according to the research integrity rules in their country. If the authors provide either an approval or a document showing that ethics approval is not needed, the review process will continue. If the authors cannot provide either documents, the manuscript will be rejected. For articles concerning experimental research on humans, a statement should be included that shows informed consent of patients and volunteers was obtained following a detailed explanation of the procedures that they may undergo.

Informed consent must also be obtained for case reports. All recognizable photographs of a patient must be accompanied by written permission from the patient for reproduction. Procedures that were performed to eliminate any pain, harm and distress in subjects/animals should clearly be stated. The authors should clearly state their compliance with internationally accepted guidelines and the guidelines issued by the relevant authority of their country. The journal requests a copy of the Ethics Committee Approval received from the relevant authority.

The Current Thoracic Surgery wants reviewers to treat the manuscripts in confidence. The material of the manuscripts must not be used or shared in any way until they have been published. The Current Thoracic Surgery follows the COPE flowchart in cases of suspected reviewer misconduct. Please refer to COPE ethical guidelines for peer reviewers for "Basic principles to which peer reviewers should adhere" and "Expectations from reviewers"

Our reviewers are expected to check that the art icles comply with the SAGER guidelines and encourage authors to do so. Authors should use the terms sex (biological attribute) and gender (shaped by social and cultural circumstances) carefully in order to avoid confusing both terms. Article titles and/or abstracts should indicate clearly what sex(es) the study applies to. Authors should also describe in the background, whether sex and/or gender differences may be expected; report how sex and/or gender were accounted for in the design of the study; provide disaggregated data by sex and/or gender, where appropriate; and discuss respective results. If a sex and/or gender analysis was not conducted, the rationale should be given in the discussion.

The Current Thoracic Surgery uses bibliographic databases and also accepts authors' suggestions to find new reviewers. The journal thanks to the reviewers and publishes the reviewer list every year in the last issue.

Besides the rutine questions given at the reviewers' comment page, the reviewers can also use the questions below, when reviewing the manuscripts:

1. Please do state if any conflict(s) of interest is present to review this manuscript.

2. Do you suspect any research or publication misconduct?

3. Does the manuscript contain significant information to justify publication?

4. Is the title of the article appropriate?

5. Does the abstract clearly and accurately describe the content of the article?

6. Is the problem significantly and concisely stated?

7. Are the methods of the study described comprehensively?

8. Is the results section clear and satisfactory?

9. Are the interpretations and conclusions justified by the results?

10. If adequate and current references were given?

11. Is the terminology used in the text appropriate for a medical writing?

12. Are the figure/table lagends satisfactory?

13. Is it necessary to shorten/elongate the article sections?

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